Environment Canada Environnement Canada

# OCEAN DISPOSAL CONTROL PROGRAM

## OCEAN DISPOSAL ACTIVITIES SUMMARY 1994

## REGIONAL PROGRAM REPORT: 97-02

## PACIFIC AND YUKON REGION

Canada

103-05681/

**Errata for Ocean Disposal Activities Summary 1994 Pacific and Yukon Region**

Page 3, Table 1
The volume disposed of at the Point Grey disposal site in 1994 was 355,416 cubic metres.

Page 3, Table 1
The volume disposed of at the Sand Heads disposal site in 1994 was 1,741,295 cubic metres.

Page 3, Table 1
The total volume disposed of at disposal sites in the Pacific and Yukon Region in 1994 was 2,285,411 cubic metres.

Section 5.0 Active Disposal Site Information

| Page | Disposal Site | Total Quantity Disposed Since 1976 |
|---|---|---|
| 10 | Point Grey | 6 700 465 cubic metres + 390 tonnes |
| 16 | Sand Heads | 9 132 934 cubic metres |
| 17 | Victoria | 289 403 cubic metres + 31 105 tonnes |
| 20 | Porlier Pass | 143 575 cubic metres |
| 21 | Five Finger Island | 194 822 cubic metres |
| 22 | Malaspina Strait | 463 249 cubic metres + 6000 tonnes |
| 37 | Johnstone Strait - Hickey Point | 142 187 cubic metres + 40 tonnes |

Page 10, Paragraph 2
... over 151 000 cubic metres of dredge material were disposed of at this site in 1994.

Page 16, Paragraph 3
In 1994, 1 741 295 cubic metres of material were disposed of at this site.

# OCEAN DISPOSAL ACTIVITIES SUMMARY

# 1994

# PACIFIC AND YUKON REGION

ENVIRONMENT CANADA
ENVIRONMENTAL PROTECTION

PACIFIC AND YUKON REGION

Regional Program Report No. 97 - 02

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# ABSTRACT

Environment Canada's administration of the Canadian Environmental Protection Act (CEPA) Part VI, regarding ocean disposal of wastes, is summarized in this report. Disposal activities from January 01, 1994 to December 31, 1994 in the Pacific and Yukon Region are specifically documented. The sites in this region are used primarily for disposal of dredge and excavation spoils. Activities at these sites from 1975 to 1993 have been compiled in a series of reports by Ward and Sullivan (1980), Sullivan (1987), Kim and Sullivan (1993) and Kim et al. (1997). This report is a continuation of this series and includes information on 14 disposal sites that were active in the Pacific and Yukon Region in 1994. Data are presented for monitoring done at six of these sites.



# RÉSUMÉ

Ce rapport concerne les activités d'Environnement Canada en matière d'application de la partie VI de la Loi canadienne sur la protection de l'environnement (LCPA) (dépôts de déchets en mer). Il traite plus spécifiquement d'activités de dépôt qui ont eu lieu du 1er janvier au 31 décembre 1994 dans certains sites de la région du Pacifique et du Yukon. Les sites de cette région servent principalement du dépôt des materiaux de dragage et d'excavation. Les activités de dépôt pour la période comprise entre 1975 et 1993 ont été compilées dans une série de rapports préparés par Ward et Sullivan (1980), Sullivan (1987), Kim et Sullivan (1993) et Kim et al. (1997). Ce rapport s'incrit dans cette série et contient de l'information sur les activités de 14 sites de dépôt dans la région du Pacifique et du Yukon au cours de l'année 1994. Les données fournies concernent les contrôles effectués dans six de ces sites.



# ACKNOWLEDGMENTS

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# 1.0 INTRODUCTION

Environment Canada has administered the requirements for ocean disposal of wastes since 1975 under authority of the Ocean Dumping Control Act (ODCA). In 1988 this legislation was replaced by the Canadian Environmental Protection Act (CEPA), Part VI. Material destined for ocean disposal requires a permit issued by Environment Canada. To ensure compliance with the conditions of the permit, inspections are routinely conducted by Environment Canada, Enforcement and Emergencies Division.

Within Canada, ocean disposal sites are divided into four geographical regions: Atlantic, Prairie and Northern, Quebec, and Pacific and Yukon (Figure 1 shows the Pacific and Yukon Region). This report describes all the activities conducted in 1994 by the Ocean Disposal Control Program in the Pacific and Yukon Region. There are thirty-five designated sites in the Region concerned primarily with dredge and excavation spoils. In 1994, thirteen disposal sites were used and six were monitored (Table 1). Information on activities conducted under specific permits and approvals at each disposal site can be found in the Ocean Disposal Site Summaries in Appendix I.

Figure 1. Location map.

Table 1. Active ocean disposal sites.

| Number | Disposal Site | Co-ordinates | | Volume Disposed in 1994 |
|---|---|---|---|---|
| * 1 | Point Grey | 49°15.40'N | 123°22.10'W | 381,844 m3 |
| 9 | Sand Heads | 49°06.00'N | 123°19.50'W | 1,757,406 m3 |
| * 14 | Victoria | 48°22.30'N | 123°21.80'W | 4,650 m3 |
| 32 | Porlier Pass | 49°00.20'N | 123°29.80'W | 9,100 m3 |
| 40 | Five Finger Island | 49°15.20'N | 123°54.60'W | 3,900 m3 |
| * 49 | Malaspina Strait | 49°45.00'N | 124°27.00'W | 14,550 m3 |
| 64 | Thornbrough Channel | 49°31.00'N | 123°28.20'W | 3,500 m3 |
| 65 | Watts Point | 49°38.50'N | 123°14.00'W | 8,500 m3 |
| 75 | Kingcome Inlet | 49°27.50'N | 124°05.50'W | 3,800 m3 |
| * 116 | Cape Mudge | 49°57.70'N | 125°05.00'W | 7,700 m3 |
| * 119 | Johnstone Strait - Hickey Point | 50°27.80'N | 126°04.80'W | 2,500 m3 |
| 120 | Johnstone Strait - Hanson Island | 50°33.50'N | 126°48.00'W | 8,500 m3 |
| * 121 | Malcolm Island | 50°46.40'N | 127°22.60'W | 0 m3 |
| 126 | Roberts Bank - Strait of Georgia | 49°37.52'N | 123°48.45'W | 222,000 m3 |
| **TOTAL** | | | | **2,427,950 m3** |

* Monitoring surveys were conducted at these sites in 1994.

# 2.0 ADMINISTRATION

## 2.1 APPLICATION AND REVIEW PROCESS

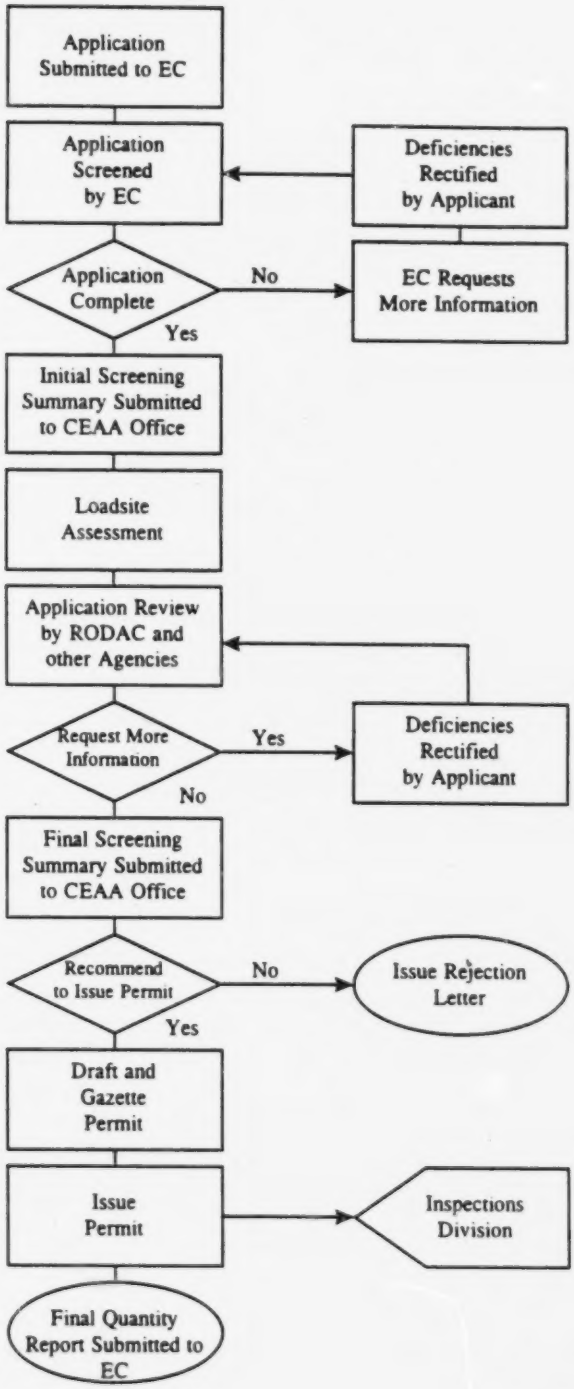
Under the authority of CEPA, Part VI, material destined for ocean disposal or loaded for the purpose of ocean disposal requires an Ocean Disposal Permit. Permit applications are reviewed by Environment Canada with advice from the Regional Ocean Disposal Advisory Committee (RODAC). This committee has representation from Environment Canada, the Department of Fisheries and Oceans, and the British Columbia Ministry of Environment, Lands and Parks. Information on the application process can be obtained from Environment Canada, 224 West Esplanade, North Vancouver, B.C., V7M 3H7. Figure 2 shows the complete permitting process.

As part of the Green Plan Initiative, amendments to Ocean Disposal Regulations are being made. Information on Phase I, the new application form and application fees is discussed in Kim et al., 1997. In Phase II environmental assessment procedures will be revised, the regulated substance list will be reviewed, and the effects of ocean disposal on the marine environment will be assessed.

The public is advised of the application via the Notice of Intent that the applicant publishes in the local newspaper at the onset of the application. The public can address their comments to Environment Canada throughout the application review process. On January 19, 1994 the Canadian Environmental Assessment Act (CEAA) replaced the Environmental Assessment Review Process (EARP) Guidelines Order Section 15. All environmental screenings can be viewed by the public at the CEAA Public Registry at 224 West Esplanade, North Vancouver, B.C., V7M 3H7.

Based on the initial review of an application, inspection and sampling may be required. Following the application review process, only the material which has been rigorously tested and found to meet the Interim Contaminant Testing Guidelines for Ocean Disposal, Pacific and Yukon Region (ICTG, Appendix II), is approved for ocean disposal. All ocean disposal permits and amendments must be published in the Canada Gazette before they are issued. After a Permit has been gazetted, a one week period is reserved for public comments before a permit becomes effective.

Maintenance dredging activities involving less than 4 000 cubic metres of dredged material, or excavation projects involving clean native till may be undertaken under the terms and conditions of a general ocean disposal permit. New dredging projects or maintenance activities involving volumes in excess of 4 000 cubic metres need a site specific permit.




**RODAC Agencies**

| | |
|---|---|
| DOE - | Pollution Prevention and Assessment Division |
| DFO - | Science and Research |
| DFO - | Habitat Management |
| MOELP - | Pollution Prevention and Remediation Branch |

**Legend**

| | |
|---|---|
| EC - | Environment Canada |
| RODAC - | Regional Ocean Disposal Advisory Committee |
| MOELP - | Ministry of Environment, Lands and Parks |
| DFO - | Department of Fisheries and Oceans |
| CEAA - | Canadian Environmental Assessment Act |

Figure 2. Ocean disposal permitting process.

## 2.2 OCEAN DISPOSAL RESTRICTIONS

Under Schedule III, Parts I and II, certain substances are prohibited or restricted from ocean disposal. In addition, the ICTG further outlines the criteria for polynuclear aromatic hydrocarbons, polychlorinated biphenyls, chlorophenols and dioxins/furans.

The substances listed in Part I are generally prohibited when present at concentrations in excess of those specified below unless, in the opinion of the Minister, the substance will be rapidly rendered harmless by physical, chemical or biological processes of the sea at the specified disposal site.

a) Organohalogen compounds:

| | |
|---|---|
| • Chlorophenols (PCP and TCP) | 1.0 µg/g |
| • Polychlorinated biphenyls (PCB) | 0.1 µg/g |
| • Polynuclear aromatic hydrocarbons (PAH) | *2.5 µg/g |
| • Dioxin (2,3,7,8 TCDD) | *quantifiable |

*ICTG rejection limit.

b) mercury and mercury compounds in a solid phase of a waste (0.75 µg/g), and in the liquid phase of a waste (1.5 µg/g);

c) cadmium and cadmium compounds in the solid phase of a waste (0.6 µg/g), and in the liquid phase of a waste (3.0 µg/g);

d) persistent plastics and other persistent synthetic materials (4% by volume), in a suitably comminuted form;

e) crude oil and its wastes, refined petroleum products, petroleum distillate residues and any mixtures containing any of those substances (any quantity that yields more than 10.0 µg/g of n-hexane soluble substances);

f) radioactive wastes and other radioactive matter (amended September 21, 1994);

g) substances in whatever form produced for biological and chemical warfare;

h) industrial waste, namely, material that comes from manufacturing or processing operations and is waste, other than (amended September 21, 1994):
   - dredged material;
   - fish waste or other organic matter that comes from industrial fish processing operations;

- ships, platforms or other anthropogenic structures at sea, provided that material capable of creating floating debris or otherwise polluting the marine environment has been removed;
- uncontaminated inert geological material; and
- uncontaminated organic matter of natural origin.

Under Part II the following substances are restricted when present in significant amounts:

a) arsenic and its compounds;
b) lead and its compounds;
c) copper and its compounds;
d) zinc and its compounds;
e) organosilicon and its compounds;
f) cyanides;
g) fluorides;
h) pesticides and their by-products not included in the List of Prohibited Substances in Part I;
I) beryllium and its compounds;
j) chromium and its compounds;
k) nickel and its compounds;
l) vanadium and its compounds;
m) containers and scrap metal;
n) deleted (amended September 21, 1994);
o) substances that by reason of their bulk would interfere with fishing;
p) substances that, though of a non-toxic nature, may become harmful due to the quantities in which they are dumped, or that are liable to seriously reduce amenities.

In dredged material, lead is considered to be present in significant amounts when contained in wastes at concentrations of 0.05% or more by weight (500 µg/g) and arsenic, copper, zinc, beryllium, chromium, nickel and vanadium when present at concentrations of 0.1% (1000 µg/g). Pacific RODAC considers these levels as general guidelines only and may impose more stringent limits.

In order to protect fisheries resources, spawning areas, and juvenile and adult migratory areas, the Department of Fisheries and Oceans (DFO) requires that dredging and/or ocean disposal activities be conducted within time frames specified by district Habitat Management Units. Proponents are directed to contact the appropriate DFO units prior to commencing any projects for timing restrictions relevant to the area of proposed activities. For example, Fraser River dredging guidelines for operations within navigation channels specify periods when clamshell or suction dredging is allowed. Dredging outside navigation channels is reviewed on a site-specific basis.

## 2.3 COMPLIANCE AND ENFORCEMENT

Environment Canada conducts pre-load inspections to confirm sampling program design and collects samples as required. CEPA inspectors routinely conduct compliance and surveillance inspections of dredging/loading and disposal operations. Vessel Traffic Management Centres monitor disposal sites to ensure disposal activities occur at the authorized locations. Any contravention of permit conditions are dealt with under authority of CEPA, Part VI or Section 36 (3) of the Fisheries Act.

# 3.0 ENVIRONMENTAL ASSESSMENT

Under Phase II of the Green Plan initiative, environmental assessment procedures are being revised. The Interim Monitoring Guidelines for Ocean Disposal were developed and field tested in 1993 and 1994. Three of five biological testing protocols—the Marine Amphipod Acute Toxicity Test, the Echinoid Fertilization Assay and the Bacterial Photoluminescence test (Microtox®)—completed in 1992, were used in field trials to assess their value in disposal site assessment. Development continues on the Polychaete Growth test and the Bioaccumulation assay protocols which are scheduled to be completed in 1995.

In addition, Environment Canada published 'Guidance document on the collection and preparation of sediments for physicochemical characterization and biological testing' in December 1994. Biological Monitoring Guidelines and Technical Guidance on Physical Monitoring documents are also being prepared for use in the program.

# 4.0 OCEAN DISPOSAL ACTIVITIES

## 4.1 NUMBER OF PERMITS

In 1994, 21 permit applications were received and 20 ocean disposal permits were issued. Two of the permits issued were for the disposal of excavation material and the rest were for disposal of dredge material.

Table 2. Number of permits issued in the Pacific and Yukon Region - 1987 to 1994.

| Permit Type | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Dredge | 33 | 41 | 28 | 25 | 23 | 20 | 21 | 18 | 209 |
| Excavation | 2 | 5 | 5 | 4 | 4 | 5 | 3 | 2 | 30 |
| Vessel | 0 | 0 | 1 | 0 | 2 | 2 | 0 | 0 | 5 |
| Others | 2 | 2 | 2 | 2 | 1 | 0 | 1 | 0 | 10 |
| **Total** | 37 | 48 | 36 | 31 | 30 | 27 | 25 | 20 | 254 |

One dredge project was partially rejected in 1994. Sediment samples taken at MacMillan Bloedel's Canadian White Pine Lumber Division found a small area which exceeded ICTG criteria. Sediments from this area were not approved for ocean disposal.

Under general permits for dredged and excavated materials, 88 projects were reviewed and approved in 1994. Thirty-six approvals were for excavation projects in the lower mainland and 52 were for dredged material.

## 4.2 VOLUME OF MATERIAL OCEAN DISPOSED

In 1994, approximately 2 450 000 cubic metres of material was sent to ocean disposal sites in the Pacific and Yukon Region. Of this total volume, more than 85% was taken to Point Grey and Sand Heads disposal sites. Excavation projects accounted for 205 000 cubic metres of the total volume.

## 4.3 MONITORING

Routine monitoring of ocean disposal sites is carried out by Environment Canada to assess physical, chemical and biological effects of disposal operations. In 1994, six disposal sites—Point Grey, Victoria, Hickey Point, Malcolm Island, Cape Mudge and Malaspina Strait—were monitored to establish chemical concentrations and physical characteristics of sediments at each site. Analysis of the sediments included trace metals, PAHs, total organic carbon and particle size distribution.

Sediment toxicity tests of sediments from the disposal sites at Point Grey, Malaspina Strait and Cape Mudge were conducted. Results of the amphipod bioassay using *Eohaustorius washingtonianus*, the echinoid fertilization assay and the solid phase Microtox® test are presented in Section 5.0.

In October 1994, video images of the Cape Mudge and Malaspina disposal sites were recorded using a remotely operated submersible, ROPOS. The ROPOS followed predetermined transect lines across the disposal site to examine bottom conditions and evidence of ocean disposal activities. Discussion of the physical monitoring surveys are presented in Section 5.0

# 5.0 ACTIVE DISPOSAL SITE INFORMATION

## 5.1 POINT GREY

| | |
|---|---|
| **Disposal Site:** | Point Grey |
| **Number:** | 1 |
| **Co-ordinates:** | 49°15.40'N; 123°22.10'W |
| **Depth:** | 210 metres |
| **Total Quantity Disposed Since 1976:** | 6 538 426 cubic metres |

**Comments**

The Department of Fisheries and Oceans request that the Vancouver Harbour and Fraser River Dredging Guidelines be applied to any dredging projects, subject to approval by the appropriate Habitat Management Unit.

**Loadsite Information**

Point Grey disposal site (Figure 3) receives all of the excavation materials destined for ocean disposal in the Pacific and Yukon Region. Over 204 000 cubic metres of excavated native till from projects in the Lower Mainland was disposed of at this site in 1994. In addition to this, over 177 000 cubic metres of dredge material was disposed of at this site in 1994.

**Monitoring Information**

A benthic chemistry survey was conducted at this disposal site in April 1994. All chemical concentrations are within the limits specified in the ICTG. Surface sediment chemistry and particle size analysis results are presented in Table 3.

In June 1994, further testing was conducted at this site. The study consisted of surface sediment chemistry, biological testing, benthic infauna and physical characterization of the disposal site. Biological test results are presented in Table 4. Limited toxic responses were found in all but one of the sediments collected. Sediment chemistry of the bioassay test sediments is presented in Table 5. Lee et al., (1995) provide further discussion of the biological test results.

Physical characterization of a disposal site is conducted to determine the area of deposition of materials and also the type of materials found within the disposal site boundaries. In 1994, a remotely operated vehicle (ROV) was deployed and sent across the disposal site twice, crossing at the centre. It was observed that materials within the disposal site have changed the substrate and benthic community of the disposal site. Where woodwaste from ocean disposal activities is apparent on the seabed, significant

colonisation has occurred. The ROV travelled beyond the edges of the disposal site confirming that no excavated or dredged material is present outside of these boundaries.

A benthic infauna study was conducted in 1994. The results indicated that the abundance of benthic macroinvertebrates in sediment from stations 4 and 29 showed a significant difference from the reference station. Sediment from station 2 showed a significant difference in species richness of benthic macroinvertebrates from that of the reference station. Complete details of the study will be presented in a separate Point Grey monitoring report (in preparation).

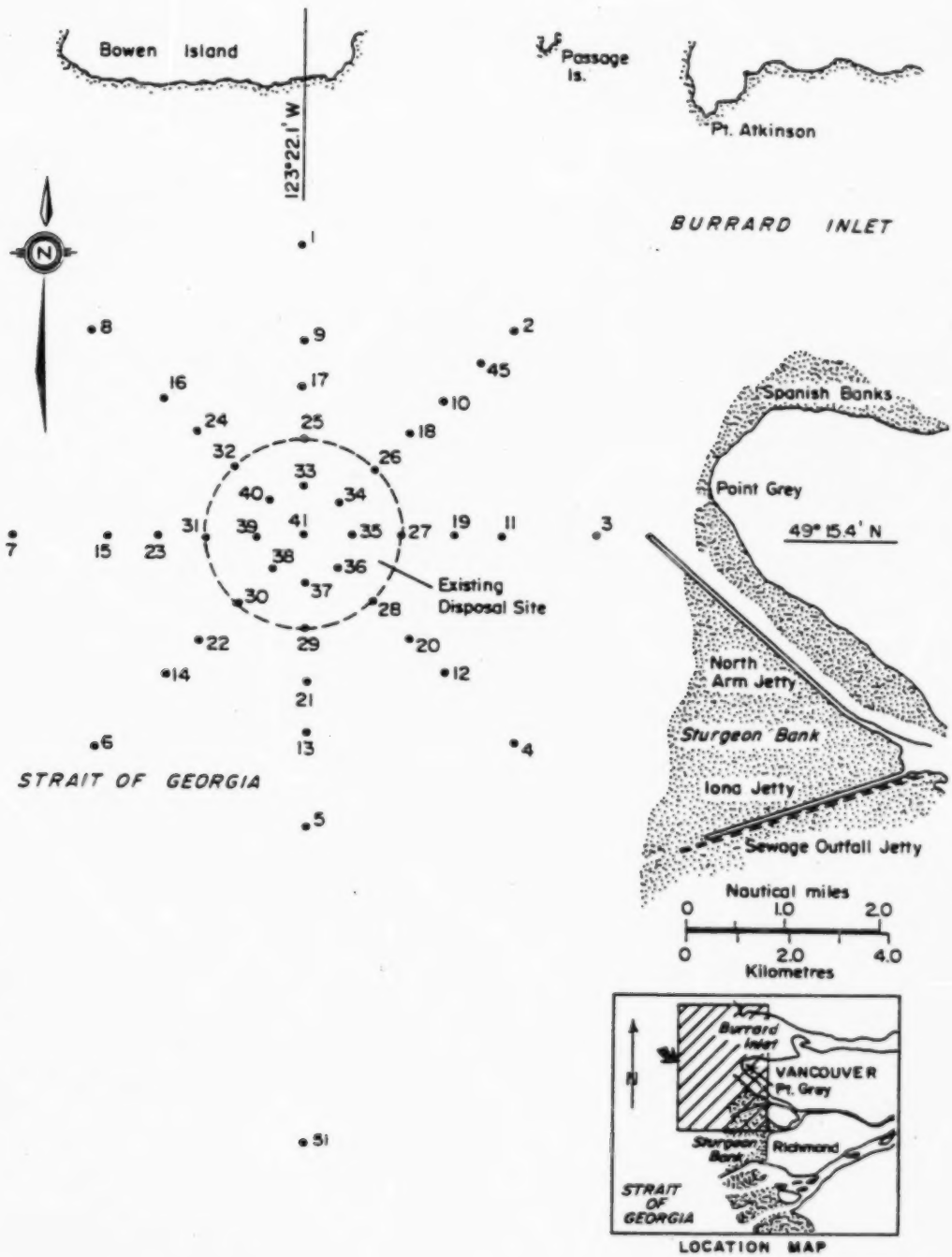



Figure 3. Point Grey ocean disposal site and sediment stations.

Table 3. Point Grey sediment chemistry and particle size - April 1994 survey.

| Station | Sediment Chemistry | | | | | | | Particle Size (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cd[1] µg/g | Cu µg/g | Hg µg/g | Pb µg/g | Zn µg/g | TPAH µg/g | TOC % | Gravel > 2.0 mm | Sand 2 - 0.063 mm | Silt 0.063 - 0.004 mm | Clay < 0.004 mm |
| 1 | 0.06 | 44.0 | 0.108 | 20 | 131 | 0.75 | 0.91 | 0.0 | 3.1 | 59.9 | 37.1 |
| 2 | 0.05 | 52.0 | 0.122 | 18 | 128 | 0.61 | 0.96 | 0.0 | 2.2 | 60.5 | 37.2 |
| 3 | 0.05 | 27.0 | 0.098 | 7 | 81 | 0.37 | 0.61 | 0.0 | 51.8 | 37.7 | 10.5 |
| 4 | 0.04 | 42.0 | 0.145 | 12 | 124 | 0.47 | 1.02 | 0.0 | 1.4 | 62.9 | 35.7 |
| 5 | 0.04 | 38.0 | 0.171 | 11 | 126 | 0.47 | 1.11 | 0.0 | 1.4 | 65.1 | 33.9 |
| 6 | 0.25 | 39.0 | 0.194 | 12 | 129 | 0.60 | 1.09 | 0.0 | 1.1 | 60.8 | 38.0 |
| 7 | 0.05 | 45.0 | 0.206 | 19 | 142 | 0.66 | 1.05 | 0.9 | 1.5 | 59.4 | 38.2 |
| 8 | 0.07 | 50.0 | 0.229 | 22 | 143 | 0.66 | 1.12 | 0.0 | 2.7 | 60.5 | 36.8 |
| 25 | 0.10 | 35.0 | 0.219 | 11 | 113 | 0.73 | 1.75 | 0.1 | 24.3 | 51.6 | 24.0 |
| 27 | 0.08 | 24.0 | 0.120 | 9 | 79 | 0.62 | 0.98 | 3.0 | 48.2 | 35.5 | 13.3 |
| 29 | 0.04 | 36.0 | 0.175 | 11 | 113 | 0.52 | 0.91 | 0.0 | 20.0 | 54.9 | 27.2 |
| 31 | 0.04 | 44.0 | 0.177 | 17 | 132 | 0.89 | 1.03 | 0.3 | 12.4 | 53.9 | 33.3 |
| 34 | 0.03 | 30.0 | 0.103 | 7 | 80 | 0.92 | 0.86 | 28.0 | 50.1 | 16.1 | 5.8 |
| 36 | 0.38 | 34.0 | 0.328 | 8 | 118 | 0.57 | 1.35 | 2.2 | 34.4 | 46.7 | 16.7 |
| 38 | 0.09 | 36.0 | 0.100 | 12 | 115 | 0.68 | 1.26 | 2.6 | 17.2 | 46.9 | 31.2 |
| 40 | 0.05 | 37.0 | 0.098 | 13 | 118 | 1.43 | 1.83 | 1.7 | 24.9 | 47.8 | 25.7 |
| Reference | 0.05 | 37.0 | 0.156 | 10 | 116 | 0.44 | 1.01 | 0.0 | 3.5 | 69.3 | 27.2 |

Mean values reported; N = 3.

[1] Trace metal analyses are presented as total metals.

Table 4. Point Grey bioassay test results - June 1994 survey.

| Station | Amphipod *E. washingtonianus* % Survival | | Echinoid *L. pictus* % Fertilization | | Microtox® Solid Phase |
|---|---|---|---|---|---|
| | Test Sediment | Control | Test Sediment | Control | IC50 % Effect |
| 25 | * 41.0 ± 19 | 95 ± 3.5 | 57.5 ± 10 | 79.3 ± 2.8 | 0.131 |
| 27 | 77.0 ± 4.5 | 93 ± 4.5 | * 50.0 ± 6.7 | 79.3 ± 2.8 | 0.111 |
| 29 | 64.0 ± 9.6 | 93 ± 4.5 | * 24.5 ± 4.7 | 79.3 ± 2.8 | 0.160 |
| 31 | 72.0 ± 10 | 93 ± 4.5 | 60.5 ± 6.9 | 79.3 ± 2.8 | * 0.057 |
| 34 | 70.0 ± 12 | 93 ± 4.5 | * 52.3 ± 3.0 | 79.3 ± 2.8 | 0.107 |
| 36 | 69.0 ± 7.4 | 93 ± 4.5 | * 51.5 ± 5.2 | 79.3 ± 2.8 | 0.100 |
| 38 | * 40.0 ± 22 | 95 ± 3.5 | * 38.8 ± 3.8 | 79.3 ± 2.8 | * 0.087 |
| 40 | 80.0 ± 6.1 | 95 ± 3.5 | 54.8 ± 3.8 | 79.3 ± 2.8 | 0.256 |

Mean values reported for amphipod and echinoid; N = 5.
* Indicates toxic response.

Table 5. Point Grey bioassay sample sediment chemistry - June 1994 survey.

| Station | Sediment Chemistry | | | | | Particle Size (%) | | |
|---|---|---|---|---|---|---|---|---|
| | Cd[2] µg/g | Pb µg/g | Hg µg/g | TPAH µg/g | TOC % | Gravel > 2.0 mm | Sand 2 - 0.063 mm | Silt and Clay < 0.063 mm |
| 25 | 0.18 | 16 | 0.080 | 0.76 | 1.18 | 0.2 | 23.5 | 76.3 |
| 27 | 0.10 | 9 | 0.059 | 0.72 | 2.20 | 0.4 | 29.5 | 70.1 |
| 29 | 0.06 | 13 | 0.077 | 0.56 | 1.48 | 1.4 | 21.3 | 77.3 |
| 31 | 0.07 | 22 | 0.100 | 1.30 | 1.23 | 0.6 | 18.9 | 80.5 |
| 34 | 0.09 | 12 | 0.070 | 1.32 | 1.62 | 3.7 | 41.1 | 55.2 |
| 36 | 0.07 | 11 | 0.073 | 1.53 | 0.93 | 1.4 | 29.3 | 69.3 |
| 38 | 0.07 | 13 | 0.082 | 0.83 | 1.16 | 0.1 | 22.0 | 77.9 |
| 40 | 0.52 | 11 | 0.068 | 0.62 | 1.26 | 3.1 | 35.5 | 61.4 |

[2] Trace metal analyses are presented as total metals.

## 5.2 SAND HEADS

| | |
|---|---|
| **Disposal Site:** | Sand Heads |
| **Number:** | 9 |
| **Co-ordinates:** | 49°06.00'N; 123°19.50'W |
| **Depth:** | 70 metres |
| **Total Quantity Disposed Since 1976:** | 8 930 999 cubic metres |

### Comments

The Fraser River Dredging Guidelines, as developed by the Department of Fisheries and Oceans, apply to all projects. Clamshell dredging may be conducted throughout the year, subject to site specific approval. Suction dredges must operate at five metres depth at low tide from March 1st to June 1st. In even-numbered years the use of suction dredges is prohibited from around April 15th to May 15th, during the downstream migration of pink salmon.

The Department of Fisheries and Oceans' Habitat Management Unit in New Westminster should be contacted for specific timing restrictions for dredging.

### Loadsite Information

In 1994, 1 757 406 cubic metres of material were disposed of at this site. Only clean sand, silt and gravel are approved for disposal at the Sand Heads site. The majority of material disposed of at this site originated from Fraser River channel maintenance projects by Public Works and Government Services Canada.

## 5.3 VICTORIA

| | |
|---|---|
| **Disposal Site:** | Victoria |
| **Number:** | 14 |
| **Co-ordinates:** | 48°22.30'N; 123°21.80'W |
| **Depth:** | 90 metres |
| **Total Quantity Disposed Since 1976:** | 259 274 cubic metres + 305 tonnes |

### Comments

The Department of Fisheries and Oceans' Habitat Management Unit in Nanaimo should be contacted for specific timing restrictions for dredging.

### Loadsite Information

A total of 4 650 cubic metres of dredged material from the Oak Bay Marina in Victoria was disposed of at this site (Figure 4) in 1994.

### Monitoring Information

A benthic sediment chemistry monitoring survey took place in 1994. Results of the survey are presented in Table 6. All chemical concentrations are below the screening limits outlined in the ICTG.

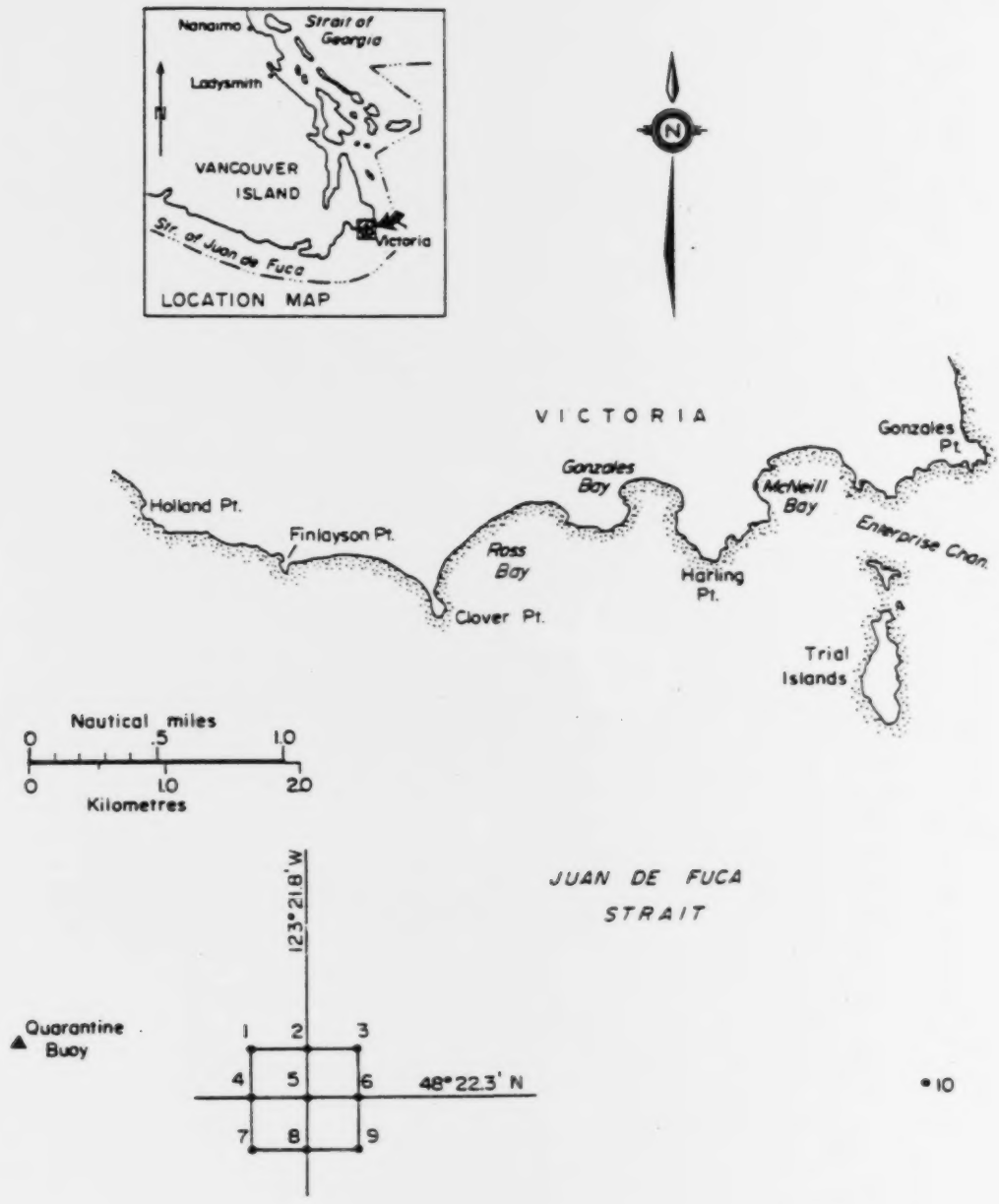



Figure 4. Victoria ocean disposal site and sediment stations.

Table 6. Victoria sediment chemistry and particle size - April 1994 survey.

| Station | Sediment Chemistry | | | | | | | Particle Size (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Cd[3] µg/g | Cu µg/g | Hg µg/g | Pb µg/g | Zn µg/g | TPAH µg/g | TOC % | Gravel > 2.0 mm | Sand 2 - 0.063 mm | Silt and Clay < 0.063 mm |
| 1 | 0.06 | 15.0 | 0.040 | 5 | 62 | 0.24 | 0.41 | 42.3 | 53.2 | 5.1 |
| 3 | 0.06 | 12.0 | 0.041 | 5 | 57 | 0.55 | 0.30 | 33.3 | 62.2 | 5.1 |
| 5 | 0.02 | 11.0 | 0.033 | 5 | 50 | 0.12 | 0.27 | 23.8 | 73.3 | 2.9 |
| 6 | 0.02 | 24.0 | 0.035 | 5 | 62 | 0.36 | 0.37 | 38.1 | 58.9 | 3.1 |
| 7 | 0.03 | 17.0 | 0.041 | 6 | 55 | 0.15 | 0.19 | 34.0 | 62.7 | 3.3 |
| 8 | 0.02 | 9.0 | 0.031 | 4 | 47 | 0.12 | 0.16 | 20.6 | 76.4 | 3.0 |
| 9 | 0.02 | 10.0 | 0.025 | 4 | 51 | 0.07 | 0.16 | 34.1 | 63.8 | 2.0 |
| 10 | 0.03 | 9.0 | 0.033 | 4 | 53 | 0.06 | 0.27 | 34.2 | 63.9 | 2.0 |

Mean values reported; N = 3.

[3] Trace metal analyses are presented as total metals.

## 5.4 PORLIER PASS

| | |
|---|---|
| **Disposal Site:** | Porlier Pass |
| **Number:** | 32 |
| **Co-ordinates:** | 49°00.20'N; 123°29.80'W |
| **Depth:** | 200 metres |
| **Total Quantity Disposed Since 1976:** | 140 035 cubic metres |

### Comments

The Department of Fisheries and Oceans' Habitat Management Unit in Nanaimo should be contacted for specific timing restrictions for dredging.

### Loadsite Information

Dredging projects at various forest industries in Chemainus, Ladysmith and Nanaimo resulted in the disposal of 9 100 cubic metres of dredged material at this site in 1994.

## 5.5 FIVE FINGER ISLAND

| | |
|---|---|
| **Disposal Site:** | Five Finger Island |
| **Number:** | 40 |
| **Co-ordinates:** | 49°15.20'N; 123°54.60'W |
| **Depth:** | 280 metres |
| **Total Quantity Disposed Since 1976:** | 194 912 cubic metres |

### Comments

For dredging and disposal timing restrictions contact the Department of Fisheries and Oceans' Habitat Management Unit, in Nanaimo.

### Loadsite Information

A total of 3 900 cubic metres of dredged material resulting from annual maintenance activities at Doman's Forest Products at Duke Point and Harmac Pacific were disposed of at the site.

## 5.6 MALASPINA STRAIT

| | |
|---|---|
| **Disposal Site:** | Malaspina Strait |
| **Number:** | 49 |
| **Co-ordinates:** | 49°45.00'N; 124°27.00'W |
| **Depth:** | 320 metres |
| **Total Quantity Disposed Since 1976:** | 351 249 cubic metres + 6 000 tonnes |

**Comments**

For dredging and disposal timing restrictions contact the Department of Fisheries and Oceans' Habitat Management Unit in Nanaimo.

**Loadsite Information**

A total of 14 550 cubic metres was disposed of at this site (Figure 5) in 1994.

Approximately 13 000 cubic metres of woodwaste from annual maintenance dredging activity at MacMillan Bloedel's Power River Division was disposed of at the site. The remaining material originated from the MacMillan Bloedel Stillwater Division.

**Monitoring Information**

Sediment chemistry, biological toxicity testing, benthic infauna, and a remotely operated vehicle (ROV) study were undertaken in 1994.

Results of the sediment chemistry analyses are presented in Table 7. Sediments from three of nine stations showed slightly elevated TPAH concentrations. The calculated 95% upper confidence limit (UCL) for TPAH concentration in sediments at the disposal site is 2.63 µg/g which exceeds ICTG limits.

Bioassay test results are presented in Table 8. Three tests were performed and limited toxic responses were observed in seven of the nine sediments. Chemical analyses of the bioassay samples are presented in Table 9. There does not appear to be any correlation of the sediment chemistry with the test results however, amphipod survival was negatively correlated with percent clay ($r = -0.854$). Please refer to Lee et al., 1995, for further discussion of biological test results.

Physical characterization of a disposal site is conducted to determine the area of deposition of materials and also the type of materials found within the disposal site boundaries. In 1994, a ROV was deployed and sent across the disposal site twice, crossing at the centre. It was observed that materials within the disposal site have

changed the substrate of the disposal site. Where woodwaste from ocean disposal activities is apparent on the seabed, significant colonisation has occurred. The ROV travelled beyond the edges of the disposal site confirming that no dredged material is present outside of these boundaries.

Benthic community analyses were conducted on sediments collected at Malaspina Strait disposal site. It was found that the abundance and diversity of macroinvertebrates in sediments from this disposal site were not significantly different from that of the reference station at Pender Harbour. Complete analyses are attached in Appendix III.

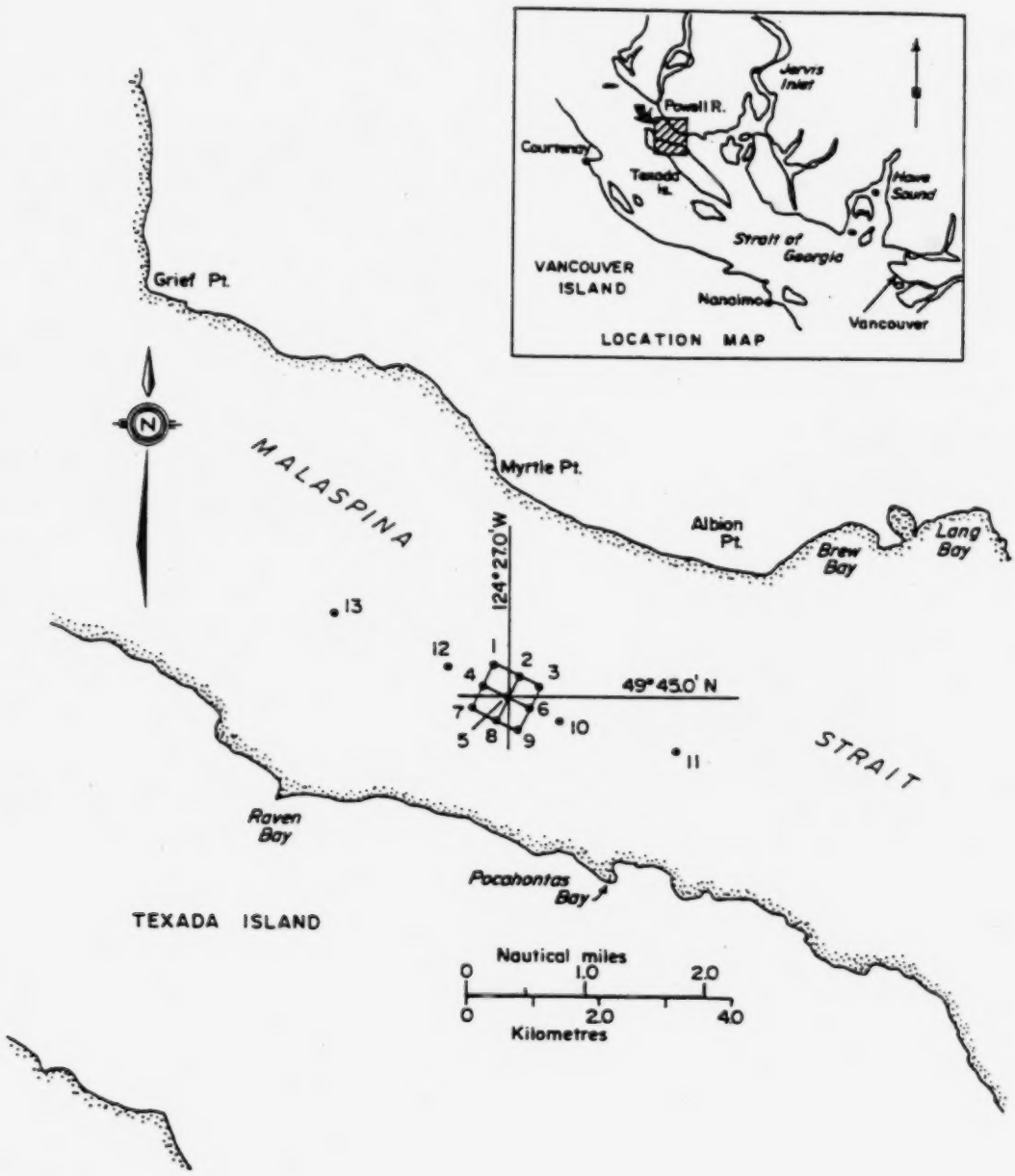



Figure 5. Malaspina Strait ocean disposal site and sediment stations.

Table 7. Malaspina Strait sediment chemistry and particle size - June 1994 survey.

| Station | Sediment Chemistry | | | | | | | Particle Size (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Cd[4] µg/g | Cu µg/g | Hg µg/g | Pb µg/g | Zn µg/g | TPAH µg/g | TOC % | Gravel > 2.0 mm | Sand 2 - 0.063 mm | Silt & Clay < 0.063 mm |
| 1 | 0.52 | 73 | 0.201 | 23 | 215 | 1.62 | 3.48 | 2.8 | 22.5 | 74.7 |
| 2 | 0.42 | 60 | 0.166 | 21 | 178 | 2.37 | 4.15 | 2.2 | 37.3 | 60.5 |
| 3 | 0.58 | 73 | 0.173 | 16 | 208 | 1.71 | 4.29 | 1.9 | 23.5 | 74.6 |
| 4 | 0.54 | 67 | 0.173 | 24 | 199 | 2.09 | 4.51 | 8.1 | 34.8 | 57.2 |
| 5 | 0.57 | 66 | 0.174 | 15 | 185 | * 3.44 | 6.97 | 1.7 | 38.0 | 60.3 |
| 6 | 0.58 | 69 | 0.185 | 16 | 204 | * 2.54 | 6.63 | 15.4 | 42.2 | 42.4 |
| 7 | 0.59 | 71 | 0.178 | 25 | 198 | * 2.84 | 4.54 | 5.5 | 34.4 | 60.1 |
| 8 | 0.51 | 69 | 0.159 | 20 | 182 | 1.91 | 5.72 | 10.0 | 32.4 | 57.5 |
| 9 | 0.42 | 62 | 0.163 | 22 | 180 | 1.73 | 5.32 | 14.2 | 34.3 | 51.5 |

Mean values reported; N = 3.

* Indicates concentration above ICTG limits.

[4] Trace metal analyses are presented as total metals.

Table 8. Malaspina Strait bioassay test results - June 1994 survey.

| Station | Amphipod *E. washingtonianus* % Survival | | Echinoid *L. pictus* % Fertilization | | Microtox® Solid Phase |
|---|---|---|---|---|---|
| | Test Sediment | Control | Test Sediment | Control | IC50 % Effect |
| 1 | * 46.3 ± 21 | 85 ± 7.1 | 43.5 ± 2.7 | 66.0 ± 2.5 | 0.235 |
| 2 | * 51.6 ± 17 | 85 ± 7.1 | * 31.5 ± 2.7 | 66.0 ± 2.5 | 0.175 |
| 3 | 59.0 ± 15 | 85 ± 7.1 | * 35.8 ± 2.4 | 66.0 ± 2.5 | 0.217 |
| 4 | 60.0 ± 5.0 | 85 ± 7.1 | * 36.8 ± 4.4 | 66.0 ± 2.5 | * 0.084 |
| 5 | 60.0 ± 21 | 85 ± 7.1 | 44.5 ± 6.0 | 66.0 ± 2.5 | * 0.098 |
| 6 | 54.7 ± 14 | 85 ± 7.1 | 47.3 ± 8.2 | 66.0 ± 2.5 | * 0.070 |
| 7 | * 43.0 ± 18 | 93 ± 4.5 | 94.0 ± 1.8 | 90.0 ± 2.8 | 0.206 |
| 8 | 75.0 ± 7.9 | 93 ± 4.5 | 95.5 ± 3.1 | 90.0 ± 2.8 | 0.113 |
| 9 | 80.0 ± 15 | 93 ± 4.5 | 96.0 ± 2.8 | 90.0 ± 2.8 | 0.114 |
| Pender Harbour | * 13.7 ± 9.6 | 85 ± 7.1 | 95.3 ± 2.8<br>* 44.5 ± 3.4 | 90.0 ± 2.8<br>66.0 ± 2.5 | 0.184 |
| Halibut Bank | * 24.0 ± 15 | 95 ± 3.5 | * 51.0 ± 6.7<br>67.3 ± 3.3 | 79.3 ± 2.8<br>80.3 ± 3.1 | 0.316 |

Mean values reported for amphipod and echinoid tests; N = 5.
* Indicates toxic response.

Table 9. Malaspina Strait bioassay sample sediment chemistry - June 1994 survey.

| Station | Sediment Chemistry | | | | | Particle Size (%) | | |
|---|---|---|---|---|---|---|---|---|
| | Cd[5] µg/g | Pb µg/g | Hg µg/g | TPAH µg/g | TOC % | Gravel > 2.0 mm | Sand 2 - 0.063 mm | Silt & Clay < 0.063 mm |
| 1 | * 0.69 | 23 | 0.192 | 1.52 | 1.98 | 0.0 | 8.7 | 91.3 |
| 2 | 0.58 | 23 | 0.168 | 1.60 | 2.62 | 0.0 | 12.4 | 87.6 |
| 3 | * 0.61 | 23 | 0.164 | 1.39 | 2.71 | 0.2 | 14.0 | 85.8 |
| 4 | 0.49 | 19 | 0.151 | 1.72 | 3.67 | 6.2 | 25.7 | 68.1 |
| 5 | 0.60 | 19 | 0.150 | 1.92 | 4.10 | 1.0 | 26.3 | 72.7 |
| 6 | * 0.61 | 21 | 0.153 | * 2.73 | 4.17 | 1.3 | 29.1 | 69.6 |
| 7 | * 0.77 | nd | 0.323 | 1.82 | 3.39 | 0.5 | 11.3 | 88.2 |
| 8 | < 0.02 | 22 | 0.140 | * 4.26 | 3.98 | 0.7 | 19.0 | 80.3 |
| 9 | < 0.02 | 22 | 0.152 | 2.04 | 4.47 | 1.5 | 29.7 | 68.8 |
| Pender Harbour | nd | 26 | 0.146 | 0.98 | 1.32 | 0.0 | 1.7 | 98.3 |
| Halibut Bank | < 0.02 | 26 | 0.126 | 0.84 | 1.01 | 0.0 | 0.4 | 99.6 |

nd = not detected

* Indicates concentration exceeded ICTG limits.

[5] Trace metal analyses are presented as total metals.

## 5.7 THORNBROUGH CHANNEL

| | |
|---|---|
| **Disposal Site:** | Thornbrough Channel |
| **Number:** | 64 |
| **Co-ordinates:** | 49°31.00'N; 123°28.30'W |
| **Depth:** | 220 metres |
| **Total Quantity Disposed Since 1976:** | 58 861 cubic metres |

**Comments**

For dredging and disposal timing restrictions contact the Department of Fisheries and Oceans' Habitat Management Unit in Steveston.

**Loadsite Information**

Maintenance dredging activity at the Terminal Forest Products in Howe Sound resulted in the disposal of 3 500 cubic metres of dredged material at this site.

## 5.8 WATTS POINT

| | |
|---|---|
| **Disposal Site:** | Watts Point |
| **Number:** | 65 |
| **Co-ordinates:** | 49°38.50'N; 123°14.00'W |
| **Depth:** | 230 metres |
| **Total Quantity Disposed Since 1976:** | 477 016 cubic metres |

### Comments

For dredging and disposal timing restrictions contact the Department of Fisheries and Oceans' Habitat Management Unit in Steveston.

### Loadsite Information

A total of 8 500 cubic metres of dredged material from various forest industries in Howe Sound was disposed of at this site.

## 5.9 KINGCOME INLET

| | |
|---|---|
| **Disposal Site:** | Kingcome Inlet |
| **Number:** | 75 |
| **Co-ordinates:** | 50°55.00'N; 126°13.00'W |
| **Depth:** | 128 metres |
| **Total Quantity Disposed Since 1976:** | 48 149 cubic metres |

### Comments

For dredging and disposal timing restrictions contact the Department of Fisheries and Oceans' Habitat Management Unit in Port Hardy.

### Loadsite Information

In 1994, 3 800 cubic metres of dredged material from the Interfor site in Kingcome Inlet were taken to the Kingcome Inlet disposal site.

## 5.10 CAPE MUDGE

| | |
|---|---|
| **Disposal Site:** | Cape Mudge |
| **Number:** | 116 |
| **Co-ordinates:** | 49°57.70'N; 125°05.00'W |
| **Depth:** | 200 metres |
| **Total Quantity Disposed Since 1976:** | 138 653 cubic metres |

### Comments

The Department of Fisheries and Oceans generally prohibits dredging/loading activities during the period December 1st to March 15th in the Campbell River area to protect salmon stocks and to minimize disruption of the local sport fishery. Ling cod utilize bottom areas in the vicinity of the disposal site.

For specific dredging and disposal timing restrictions contact the Department of Fisheries and Oceans' Habitat Management Unit in Nanaimo.

### Loadsite Information

A total of 7 700 cubic metres of dredged material from MacMillan Bloedel, Menzies Bay Division was taken to this disposal site (Figure 6) in 1994.

### Monitoring Information

Sediment chemistry, biological testing, benthic infauna, and a ROPOS study were undertaken in 1994. Results of sediment chemistry analyses are presented in Table 10. All chemical concentrations were within the ICTG limits.

Bioassay test results are presented in Table 11. Toxic responses were observed in sediments from five stations for the echinoid test. Sediment chemistry of the bioassay samples is presented in Table 12. There were no chemical concentrations above ICTG limits. For further discussion of bioassay test results please refer to Lee et al., 1995.

Physical characterization of a disposal site is conducted to determine the area of deposition of materials and also the type of materials found within the disposal site boundaries. In 1994, a remotely operated vehicle (ROV) was deployed across the disposal site. Where woodwaste from ocean disposal activities is apparent on the seabed, significant colonisation has occurred. The ROV travelled beyond the edge of the disposal site perimeter confirming that minimal dredged material is present outside the designated site.

Benthic community analyses were also conducted on sediment from Cape Mudge disposal site and compared to sediment from Halibut Bank. It was found that abundance and diversity of macroinvertebrates at the disposal site exceeds that of the reference site. Complete test results are presented in Appendix III.

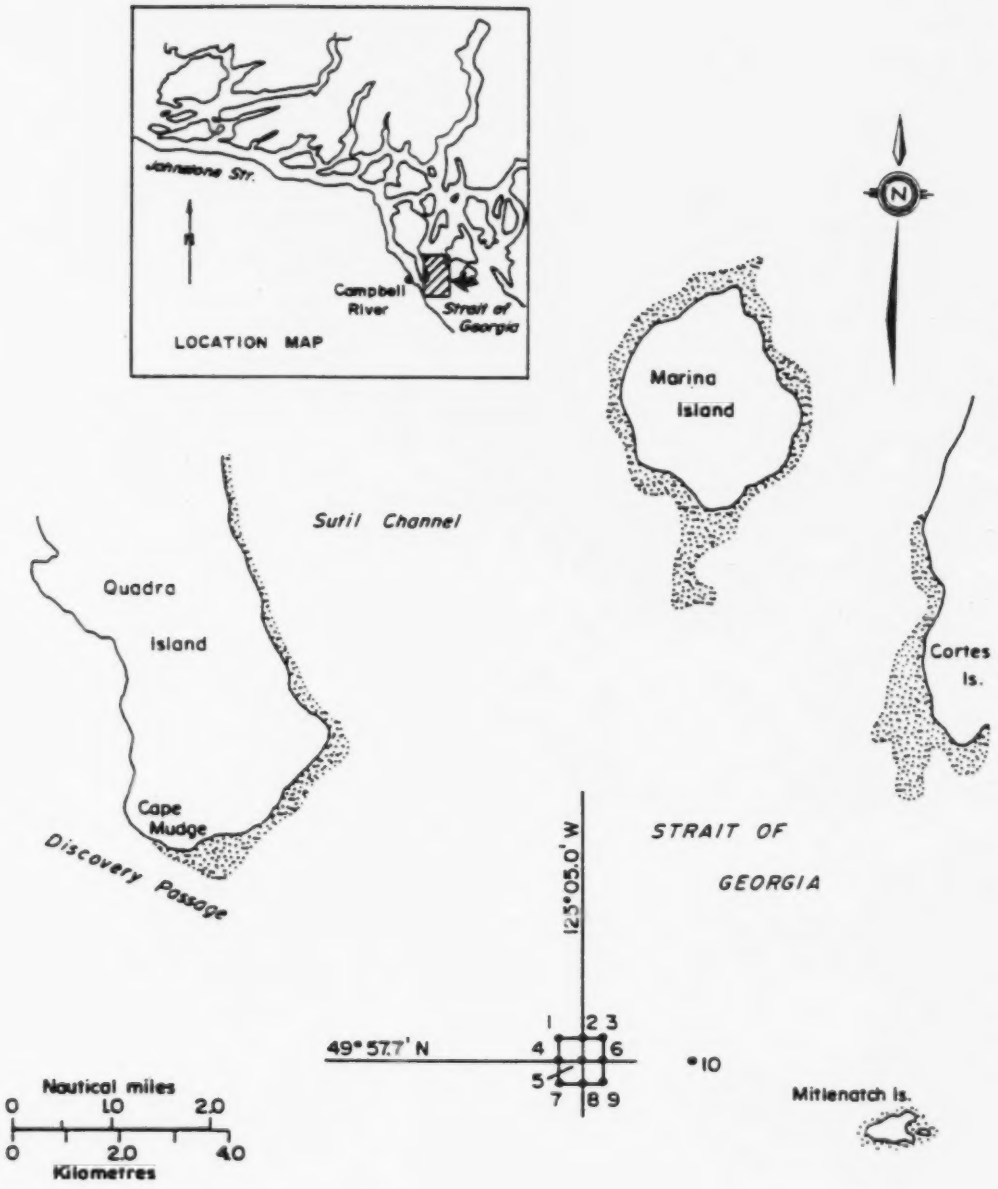



Figure 6. Cape Mudge ocean disposal site and sediment stations.

Table 10. Cape Mudge sediment chemistry and particle size - June 1994 survey.

| Station | Sediment Chemistry | | | | | | | Particle Size (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Cd[6] µg/g | Cu µg/g | Hg µg/g | Pb µg/g | Zn µg/g | TPAH µg/g | TOC % | Gravel > 2.0 mm | Sand 2 - 0.063 mm | Silt & Clay < 0.063 mm |
| 1 | 0.04 | 26 | 0.033 | 4 | 51 | 0.19 | 1.11 | 5.4 | 83.4 | 11.2 |
| 2 | 0.06 | 32 | 0.053 | 6 | 61 | 1.62 | 1.32 | 1.7 | 90.1 | 8.2 |
| 3 | 0.09 | 46 | 0.083 | 11 | 88 | 0.46 | 1.78 | 0.3 | 74.2 | 25.5 |
| 4 | < 0.02 | 23 | 0.037 | 6 | 52 | 0.14 | 1.11 | 2.5 | 90.4 | 7.2 |
| 5 | 0.03 | 32 | 0.063 | 8 | 66 | 0.25 | 1.35 | 4.4 | 88.1 | 7.6 |
| 6 | 0.05 | 36 | 0.067 | 9 | 86 | 0.66 | 1.31 | 4.9 | 73.8 | 17.6 |
| 7 | 0.05 | 29 | 0.217 | 4 | 64 | 0.24 | 1.55 | 6.7 | 85.0 | 8.3 |
| 8 | 0.03 | 30 | 0.050 | 5 | 70 | 0.22 | 0.93 | 4.8 | 86.2 | 9.0 |
| 9 | 0.04 | 34 | 0.063 | 6 | 79 | 0.29 | 1.21 | 3.0 | 82.6 | 14.3 |

Mean values reported; N = 3.

[6] Trace metal analyses are presented as total metals.

Table 11. Cape Mudge bioassay test results - June 1994 survey.

| Station | Amphipod *E. washingtonianus* % Survival | | Echinoid *L. pictus* % Fertilization | | Microtox® Solid Phase |
|---|---|---|---|---|---|
| | Test Sediment | Control | Test Sediment | Control | IC50 % Effect |
| 1 | 82.0 ± 14 | 95 ± 3.5 | 64.5 ± 6.6 | 80.3 ± 3.1 | 1.855 |
| 2 | 85.0 ± 7.1 | 95 ± 3.5 | 64.0 ± 6.9 | 80.3 ± 3.1 | 0.686 |
| 3 | 81.0 ± 12 | 95 ± 3.5 | 64.0 ± 5.5 | 80.3 ± 3.1 | 0.356 |
| 4 | 98.0 ± 2.7 | 95 ± 3.5 | * 21.8 ± 5.7 | 65.8 ± 2.8 | 1.878 |
| 5 | 90.0 ± 9.4 | 96 ± 4.2 | * 24.8 ± 6.7 | 65.8 ± 2.8 | 0.616 |
| 6 | 96.0 ± 8.9 | 96 ± 4.2 | * 37.3 ± 2.8 | 65.8 ± 2.8 | 0.436 |
| 7 | 96.0 ± 4.2 | 96 ± 4.2 | * 18.0 ± 3.6 | 65.8 ± 2.8 | 0.890 |
| 8 | 96.0 ± 4.2 | 96 ± 4.2 | * 38.8 ± 6.4 | 65.8 ± 2.8 | 1.208 |
| 9 | 93.0 ± 4.5 | 96 ± 4.2 | 40.8 ± 4.1 | 65.8 ± 2.8 | 0.632 |
| Pender Harbour | * 13.7 ± 9.6 | 85 ± 7.1 | 95.3 ± 2.8<br>* 44.5 ± 3.4 | 90.0 ± 2.8<br>66.0 ± 2.5 | 0.184 |
| Halibut Bank | * 24.0 ± 15 | 95 ± 3.5 | * 51.0 ± 6.7<br>67.3 ± 3.3 | 79.3 ± 2.8<br>80.3 ± 3.1 | 0.316 |

Mean values reported for amphipod and echinoid; N = 5.

* Indicates toxic response.

Table 12. Cape Mudge bioassay sample sediment chemistry - June 1994 survey.

| Station | Sediment Chemistry | | | | | Particle Size (%) | | |
|---|---|---|---|---|---|---|---|---|
| | Cd[7] µg/g | Pb µg/g | Hg µg/g | TPAH µg/g | TOC % | Gravel >2.0 mm | Sand 2 - 0.063 mm | Silt & Clay < 0.063 mm |
| 1 | 0.10 | 3.5 | 0.036 | 0.75 | 0.70 | 1.5 | 86.2 | 12.3 |
| 2 | 0.09 | 4.1 | 0.041 | 0.31 | 1.04 | 0.5 | 79.4 | 20.1 |
| 3 | 0.17 | 7.7 | 0.077 | 0.44 | 1.51 | 0.5 | 59.5 | 40.0 |
| 4 | 0.10 | 3.4 | 0.038 | 0.22 | 0.62 | 1.4 | 84.3 | 14.3 |
| 5 | 0.10 | 4.0 | 0.041 | 0.38 | 0.78 | 3.3 | 78.3 | 18.4 |
| 6 | 0.06 | 5.6 | 0.054 | 0.31 | 0.97 | 1.1 | 69.1 | 29.8 |
| 7 | 0.10 | 2.9 | 0.039 | 0.30 | 0.85 | 1.4 | 82.7 | 15.9 |
| 8 | 0.07 | 3.6 | 0.045 | 0.46 | 0.88 | 3.4 | 77.7 | 18.9 |
| 9 | 0.10 | 4.7 | 0.050 | 0.29 | 0.94 | 1.0 | 74.1 | 24.9 |
| Pender Harbour | nd | 26.0 | 0.146 | 0.98 | 1.32 | 0.0 | 1.7 | 98.3 |
| Halibut Bank | <0.02 | 26.0 | 0.126 | 0.84 | 1.01 | 0.0 | 0.4 | 99.6 |

nd = not detected

[7] Trace metal analyses are presented as total metals.

## 5.11 JOHNSTONE STRAIT - HICKEY POINT

| | |
|---|---|
| **Disposal Site:** | Johnstone Strait - Hickey Point |
| **Number:** | 119 |
| **Co-ordinates:** | 50°27.80'N; 126°04.80'W |
| **Depth:** | 270 metres |
| **Total Quantity Disposed Since 1976:** | 142 188 cubic metres + 40 tonnes |

### Comments

Department of Fisheries and Oceans generally requests that dredging/loading activities be scheduled during the period November 1 to February 28 to protect fishery resources and minimize interference with recreational fishing.

For specific dredging and disposal timing restrictions contact the Department of Fisheries and Oceans' Habitat Management Unit in Nanaimo.

### Loadsite Information

In 1994, 2 500 cubic metres of dredged material from MacMillan Bloedel, Eve River was disposed of at this site (Figure 7).

### Monitoring Information

A benthic sediment chemistry study was conducted in 1994. Results are presented in Table 13. All chemical concentrations were within ICTG limits.

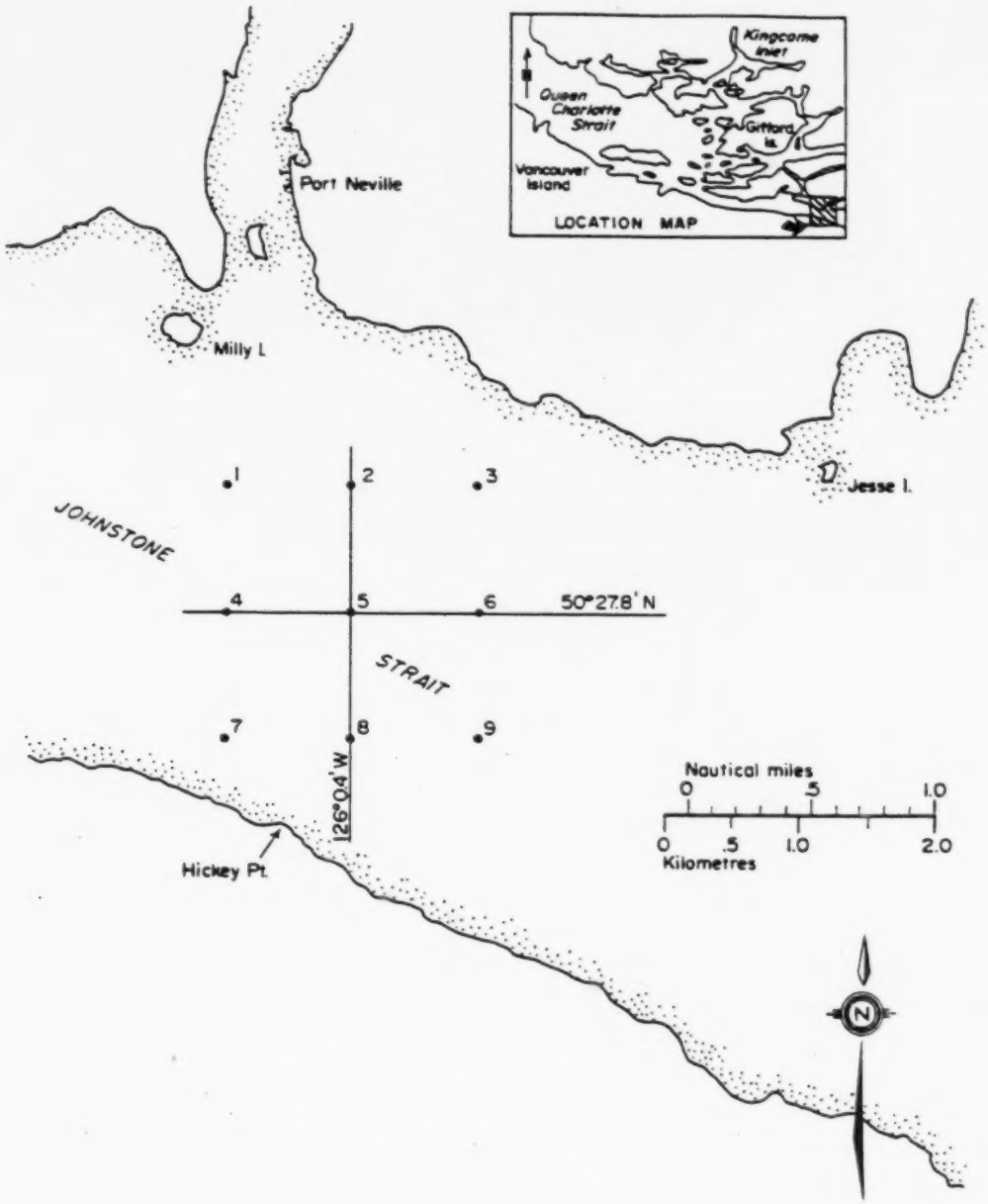



Figure 7. Johnstone Strait - Hickey Point ocean disposal site and sediment stations.

Table 13. Johnstone Strait - Hickey Point sediment chemistry and particle size - June 1994 survey.

| Station | Sediment Chemistry | | | | | | | Particle Size (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Cd[1] µg/g | Cu µg/g | Hg µg/g | Pb µg/g | Zn µg/g | TPAH µg/g | TOC % | Gravel > 2.0 | Sand 0.0625 - 2 | Silt & Clay < .0625 |
| 1 | 0.03 | 43 | 0.017 | 4 | 57 | 0.10 | 0.61 | 14.1 | 80.5 | 5.4 |
| 2 | <0.02 | 33 | 0.016 | 3 | 59 | 0.04 | 0.44 | 29.9 | 67.2 | 2.9 |
| 3 | <0.02 | 36 | 0.018 | 4 | 60 | 0.10 | 1.45 | 23.0 | 72.9 | 4.1 |
| 4 | 0.03 | 33 | 0.053 | 3 | 54 | 0.03 | 0.37 | 36.8 | 60.6 | 2.6 |
| 5 | 0.05 | 34 | 0.046 | 4 | 59 | 0.05 | 0.50 | 33.8 | 62.4 | 3.8 |
| | nd | 37 | 0.020 | 3 | 58 | 0.05 | 0.35 | 27.3 | 69.7 | 3.0 |
| | 0.02 | 29 | 0.018 | 3 | 53 | 0.03 | 0.50 | 16.5 | 79.8 | 3.7 |
| | <0.02 | 33 | 0.025 | 3 | 53 | 0.05 | 0.34 | 66.9 | 31.3 | 1.8 |
| | <0.02 | 35 | 0.103 | 2 | 54 | 0.01 | 0.27 | 31.2 | 66.8 | 2.0 |
| | 0.01 ± 0.02 | 34 ± 3 | 0.042 ± 0.03 | 3 ± 0.5 | 56 ± 2 | 0.04 ± 0.01 | 0.39 ± 0.09 | 38.2 ± 16.9 | 59.3 ± 16.4 | 2.5 ± 0.8 |
| 6 | 0.02 | 31 | 0.016 | 3 | 56 | 0.05 | 0.61 | 37.9 | 60.2 | 1.9 |
| 7 | <0.02 | 32 | 0.015 | 3 | 55 | 0.01 | 0.20 | 36.6 | 61.3 | 2.1 |
| 8 | <0.02 | 26 | 0.160 | 3 | 50 | 0.10 | 0.83 | 36.1 | 61.7 | 2.2 |
| 9 | 1.62 | 32 | 0.014 | 2 | 51 | 0.02 | 0.44 | 23.7 | 73.4 | 2.9 |

nd = not detected

[1] Trace metals analyses are presented as total metals.

## 5.12 JOHNSTONE STRAIT - HANSON ISLAND

| | |
|---|---|
| **Disposal Site:** | Johnstone Strait - Hanson Island |
| **Number:** | 120 |
| **Co-ordinates:** | 50°33.50'N; 126°48.00'W |
| **Depth:** | 350 metres |
| **Total Quantity Disposed Since 1976:** | 164 556 cubic metres |

**Comments**

The Department of Fisheries and Oceans generally prohibits dredging/loading activities during the period November 1 to February 28 to protect fishery resources and avoid interruption of the local sport fishery.

For specific dredging and disposal timing restrictions contact the Department of Fisheries and Oceans' Habitat Management Unit in Nanaimo.

**Loadsite Information**

A total of 8 500 cubic metres of dredged material from various forest related industries in Scott Cove, Beaver Cove and Port McNeill was disposed of at this site in 1994.

## 5.13 MALCOLM ISLAND

| | |
|---|---|
| **Disposal Site:** | Malcolm Island |
| **Number:** | 121 |
| **Co-ordinates:** | 50°42.00'N; 127°06.00'W |
| **Depth:** | 180 metres |
| **Total Quantity Disposed Since 1976:** | 102 960 cubic metres |

### Comments

The Malcolm Island disposal site (Figure 8) was last used in January of 1992 for the disposal of material from sawmill operations in Port McNeill.

### Monitoring Information

A benthic sediment chemistry study was conducted in June 1994. Results are presented in Table 14. There were no chemical concentrations above the ICTG limits.

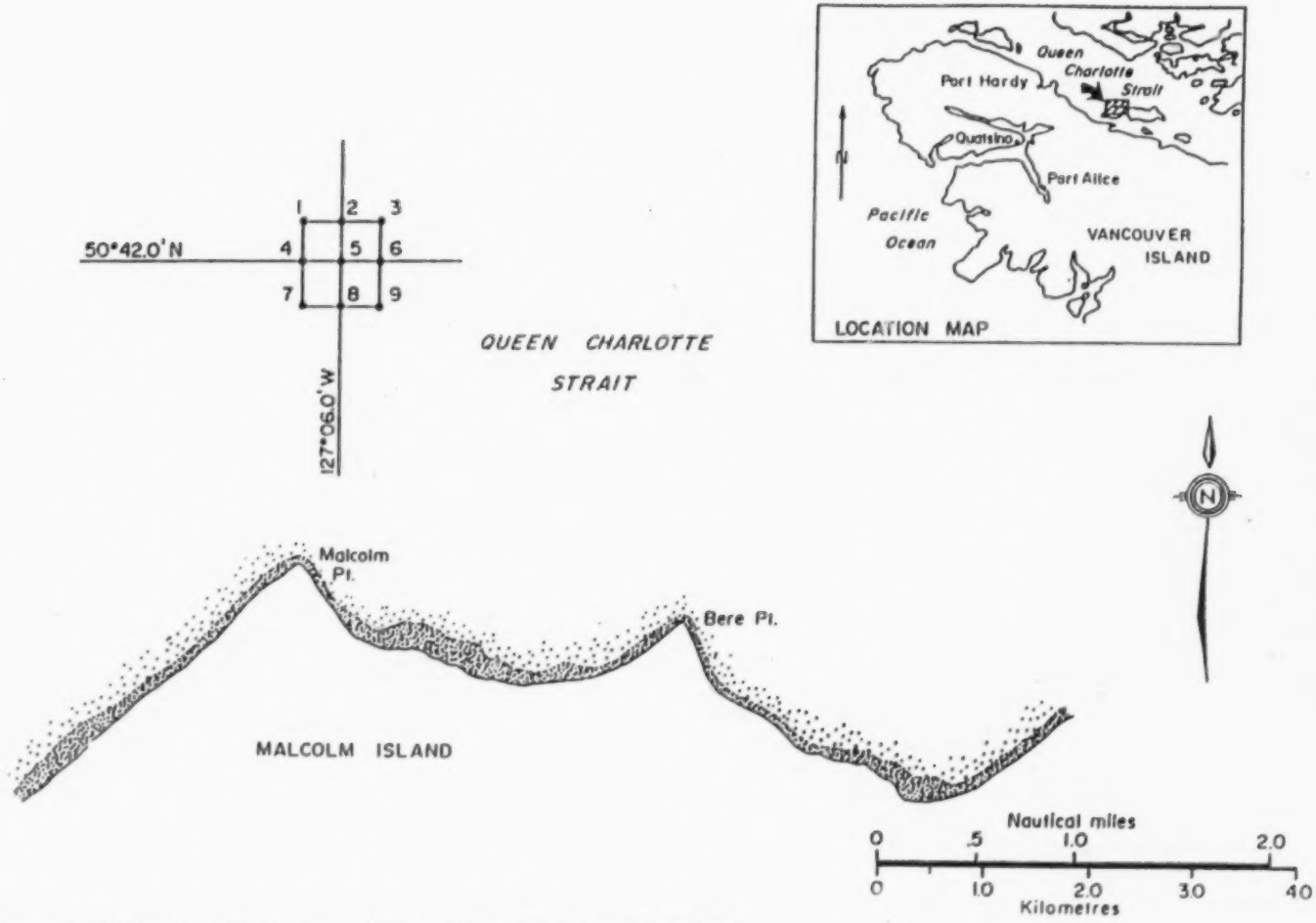



Figure 8. Malcolm Island ocean disposal site and sediment stations.

Table 14. Malcolm Island sediment chemistry and particle size - June 1994 survey.

| Station | Sediment Chemistry | | | | | | | Particle Size (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cd[9] µg/g | Cu µg/g | Hg µg/g | Pb µg/g | Zn µg/g | TPAH µg/g | TOC % | Gravel > 2.0 mm | Sand 2 - 0.063 mm | Silt 0.063 - 0.004 mm | Clay < 0.004 mm |
| 1 | 0.35 | 17 | 0.046 | 4 | 62 | 0.09 | 1.36 | 0.0 | 71.5 | 19.9 | 8.6 |
| 2 | 0.28 | 24 | 0.062 | 6 | 78 | 0.13 | 1.58 | 0.0 | 41.7 | 43.0 | 15.3 |
| 3 | 0.21 | 28 | 0.037 | 3 | 75 | 0.08 | 1.30 | 8.7 | 42.4 | 27.6 | 21.3 |
| 4 | 0.35 | 17 | 0.046 | 4 | 62 | 0.14 | 1.21 | 0.1 | 71.0 | 19.1 | 9.8 |
| 5 | nd | 16 | 0.040 | 4 | 57 | 0.09 | 0.88 | 0.0 | 74.6 | 15.3 | 10.1 |
| | 0.20 | 24 | 0.057 | 6 | 81 | 0.22 | 1.34 | 0.2 | 46.5 | 34.8 | 18.5 |
| | 0.22 | 24 | 0.057 | 6 | 72 | 0.21 | 1.70 | 0.0 | 36.9 | 46.6 | 16.5 |
| | 0.31 | 17 | 0.048 | 5 | 64 | 0.12 | 0.98 | 0.0 | 64.7 | 24.4 | 10.9 |
| | 0.07 | 14 | 0.034 | 3 | 45 | 0.06 | 0.94 | 0.2 | 70.1 | 19.9 | 9.8 |
| | 0.16 ± 0.11 | 19 ± 4 | 0.047 ± 0.01 | 5 ± 1 | 64 ± 12 | 0.14 ± 0.06 | 1.17 ± 0.31 | 0.1 ± 0.1 | 57.2 ± 14.4 | 30.3 ± 11.2 | 12.4 ± 3.6 |
| 6 | 0.10 | 30 | 0.038 | 3 | 86 | 0.38 | 1.06 | 0.2 | 8.1 | 51.7 | 40.0 |
| 7 | 0.20 | 11 | 0.025 | 2 | 38 | 0.05 | 0.55 | 0.0 | 74.7 | 18.3 | 7.0 |
| 8 | 0.65 | 16 | 0.042 | 4 | 57 | 0.12 | 0.89 | 0.0 | 74.6 | 18.2 | 7.2 |
| 9 | 0.10 | 29 | 0.044 | 4 | 90 | 0.24 | 1.43 | 0.0 | 7.9 | 50.6 | 41.5 |

nd = not detected

[9] Trace metal analyses are presented as total metals.

## 5.14 ROBERTS BANK - STRAIT OF GEORGIA

| | |
|---|---|
| **Disposal Site:** | Roberts Bank - Strait of Georgia |
| **Number:** | 126 |
| **Co-ordinates:** | 49°00.70'N; 123°10.50'W |
| **Depth:** | 40 metres |
| **Total Quantity Disposed Since 1976:** | 507 000 cubic metres |

**Loadsite Information**

The Roberts Bank disposal site was used in 1994 for the disposal of 222 000 cubic metres of material from the Deltaport project at Roberts Bank. This project was undertaken by Vancouver Port Corporation.

# 6.0 REFERENCES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# APPENDICES

# APPENDIX I

## Ocean Disposal Site Summaries

# Disposal Site History Report

For Disposal Activities Between 1/1/94 and 12/31/94

**Disposal Site** Point Grey
**Number** 1
**Lattitude** 49°15.40
**Longitude** 123°22.10
**Depth (m)** 210

| Permit Type | Permit | Loadsite | Dump Start Date | Quantity |
|---|---|---|---|---|
| Dredge | 3078 | FR-MACKENZIE MILLS | 19-Feb-94 | 750 m3 |
| | | FR-COLUMBIA BITULITHIC | 11-Mar-94 | 1000 m3 |
| | | FR-ACORN-PRIMEX | 19-Mar-94 | 1500 m3 |
| | | FRNA-WEST COAST CELLUFIBRE | 09-Apr-94 | 500 m3 |
| | | FRNA-VAN SAWMILL | 16-Apr-94 | 1500 m3 |
| | | FRNA-WEST COAST CELLUFIBRE | 01-May-94 | 1000 m3 |
| | 3080 | FR-MILL & TIMBER | 15-Jan-94 | 1500 m3 |
| | | FR-MILL & TIMBER | 02-Feb-94 | 7000 m3 |
| | | FR-MILL & TIMBER | 02-May-94 | 19000 m3 |
| | 3082 | FRNA-MB-NW | 10-Apr-94 | 1900 m3 |
| | | FRNA-MB-NW | 12-May-94 | 1600 m3 |
| | 3084 | FRNA-WESTERN WHITEWOOD | 06-Jan-94 | 800 m3 |
| | | FR-FRASER MILLS | 21-Jan-94 | 4000 m3 |
| | | FR-FRASER MILLS | 09-Feb-94 | 3000 m3 |
| | | FRNA-TERMINAL SAWMILL | 05-Mar-94 | 3000 m3 |
| | | FR-DOMANS-NW | 26-Mar-94 | 3000 m3 |
| | | FR-FRASER MILLS | 24-Apr-94 | 600 m3 |
| | | FR-SCEPTRE DREDGING | 17-May-94 | 4000 m3 |
| | 3096 | FRNA-FRASER RIVER TERMINALS | 08-Dec-94 | 8000 m3 |
| | 3108 | FRNA-RICHMOND PLYWOOD | 04-Jun-94 | 2000 m3 |
| | | FR-MILL & TIMBER | 01-Jul-94 | 3000 m3 |
| | | FRNA-WESTERN WHITEWOOD | 11-Jul-94 | 750 m3 |
| | | FRNA-REMPLE BROTHERS | 14-Jul-94 | 1200 m3 |
| | | FR-HAMMOND CEDAR | 25-Jul-94 | 4000 m3 |
| | | FR-ACORN-PRIMEX | 06-Aug-94 | 2000 m3 |
| | | FR-TILBURY ISLAND-BCFP/CN | 29-Oct-94 | 1200 m3 |
| | | FR-DELTA CEDAR | 07-Nov-94 | 1000 m3 |
| | | FR-COLUMBIA BITULITHIC | 08-Nov-94 | 1500 m3 |
| | | FR-MAINLAND SAND & GRAVEL | 09-Nov-94 | 2500 m3 |
| | | FRNA-VAN SAWMILL | 11-Nov-94 | 3000 m3 |
| | | FRNA-WESTERN WHITEWOOD | 01-Dec-94 | 700 m3 |
| | | FR-CONAG-DUCK ISLAND | 19-Dec-94 | 2800 m3 |
| | | FR-CONAG-MARPOLE | 21-Dec-94 | 1400 m3 |
| | | FR-CONAG-MITCHELL ISLAND | 22-Dec-94 | 1400 m3 |
| | | FR-CONAG-SURREY | 28-Dec-94 | 2800 m3 |
| | | FR-CONAG-DELTA | 30-Dec-94 | 1400 m3 |
| | 3109 | FR-S&R SAWMILLS | 21-Sep-94 | 26528 m3 |

# Disposal Site History Report

For Disposal Activities Between 1/1/94 and 12/31/94

| | | | | |
|---|---|---|---|---|
| Dredge | 3111 | FRNA-CANADIAN WHITE PINE | 02-Aug-94 | 8750 m3 |
| | | FRNA-MB-NW | 15-Aug-94 | 10752 m3 |
| | | FRNA-MB-NW | 28-Dec-94 | 2130 m3 |
| | 3112 | FR-MACKENZIE MILLS | 13-Aug-94 | 1500 m3 |
| | | FRNA-EBURNE | 02-Sep-94 | 1200 m3 |
| | | FRNA-WEST COAST CELLUFIBRE | 10-Sep-94 | 1500 m3 |
| | | FR-FRASER CEDAR | 24-Sep-94 | 1000 m3 |
| | | FRNA-WEST COAST CELLUFIBRE | 12-Oct-94 | 3000 m3 |
| | | FRNA-SILVERTREE SAWMILLS | 11-Nov-94 | 3000 m3 |
| | | FR-ACORN-PRIMEX | 26-Nov-94 | 1500 m3 |
| | | FRNA-WEST COAST CELLUFIBRE | 12-Dec-94 | 1000 m3 |
| | | FR-MACKENZIE MILLS | 27-Dec-94 | 4000 m3 |
| | 3116 | VAN HBR-NOVA LUMBER | 24-Jul-94 | 1500 m3 |
| | | FR-BC PACKERS | 10-Oct-94 | 1000 m3 |
| | 3119 | FR-VANCOUVER MARINA | 25-Aug-94 | 13000 m3 |
| | | | **Total Dredge Quantity:** | 177660 m3 |
| Excavation | 3085 | LOWER MAINLAND-BEL | 31-Jan-94 | 18434 m3 |
| | | LOWER MAINLAND-BEL | 01-Feb-94 | 8704 m3 |
| | | LOWER MAINLAND-BEL | 01-Mar-94 | 14106 m3 |
| | | LOWER MAINLAND-BEL | 01-Apr-94 | 21248 m3 |
| | | LOWER MAINLAND-BEL | 01-May-94 | 25278 m3 |
| | | LOWER MAINLAND-BEL | 01-Jun-94 | 5395 m3 |
| | 3091 | LOWER MAINLAND-MILLER | 30-Jan-94 | 4590 m3 |
| | | LOWER MAINLAND-MILLER | 28-Feb-94 | 2872 m3 |
| | | LOWER MAINLAND-MILLER | 31-Mar-94 | 6832 m3 |
| | | LOWER MAINLAND-MILLER | 30-Apr-94 | 5925 m3 |
| | | LOWER MAINLAND-MILLER | 31-May-94 | 2571 m3 |
| | 3115 | LOWER MAINLAND-BEL | 31-Jul-94 | 1027 m3 |
| | | LOWER MAINLAND-BEL | 31-Aug-94 | 7923 m3 |
| | | LOWER MAINLAND-BEL | 30-Sep-94 | 6812 m3 |
| | | LOWER MAINLAND-BEL | 31-Oct-94 | 11707 m3 |
| | | LOWER MAINLAND-BEL | 30-Nov-94 | 31785 m3 |
| | | LOWER MAINLAND-BEL | 31-Dec-94 | 13933 m3 |
| | 3118 | LOWER MAINLAND-MILLER | 30-Nov-94 | 5571 m3 |
| | | LOWER MAINLAND-MILLER | 31-Dec-94 | 9471 m3 |
| | | | **Total Excavation Quantity:** | 204184 m3 |
| | | | **Total Disposal Site Quantity:** | 381844 m3 |

# Disposal Site History Report

For Disposal Activities Between 01/01/94 and 31/12/94

**Disposal Site** Sand Heads
**Number** 9
**Lattitude** 49°06.00
**Longitude** 123°19.50
**Depth (m)** 70

| Permit Type | Permit | Loadsite | Dump Start Date | Quantity |
|---|---|---|---|---|
| Dredge | 3062 | FR-MAINTENANCE | 05-Jan-94 | 674000 m3 |
| | | FR-MAINTENANCE | 02-Mar-94 | 15000 m3 |
| | | FR-MAINTENANCE | 12-Mar-94 | 171000 m3 |
| | 3076 | FR-SCOTCH POND | 31-Oct-94 | 37200 m3 |
| | 3095 | FR-RIVTOW-ALASKA WAY | 15-Dec-94 | 3520 m3 |
| | | FR-RIVTOW-BARGE RAMP | 28-Dec-94 | 1400 m3 |
| | | FR-RIVTOW-BULKHEAD | 28-Dec-94 | 1700 m3 |
| | 3102 | FR-MAINTENANCE | 16-Dec-94 | 125254 m3 |
| | | FR-GULF SITE | 16-Dec-94 | 16111 m3 |
| | | FR-MAINTENANCE | 16-Dec-94 | 708221 m3 |
| | 3108 | FR-TILBURY ISLAND-BCFP/CN | 27-Sep-94 | 4000 m3 |
| | | | **Total Dredge Quantity:** | 1757406 m3 |
| | | | **Total Disposal Site Quantity:** | 1757406 m3 |

# Disposal Site History Report

For Disposal Activities Between 01/01/94 and 31/12/94

**Disposal Site** Victoria
**Number** 14
**Lattitude** 48°22.30
**Longitude** 123°21.80
**Depth (m)** 90

| Permit Type | Permit | Loadsite | Dump Start Date | Quantity |
|---|---|---|---|---|
| Dredge | 3084 | VAN IS-OAK BAY MARINA | 08-Feb-94 | 4000 m3 |
| | 3108 | VAN IS-OAK BAY MARINA | 22-Jun-94 | 650 m3 |
| | | | **Total Dredge Quantity:** | 4650 m3 |
| | | | **Total Disposal Site Quantity:** | 4650 m3 |

# Disposal Site History Report

For Disposal Activities Between 01/01/94 and 31/12/94

**Disposal Site** Porlier Pass
**Number** 32
**Lattitude** 49°00.20
**Longitude** 123°29.80
**Depth (m)** 200

| Permit Type | Permit | Loadsite | Dump Start Date | Quantity |
|---|---|---|---|---|
| Dredge | 3099 | VAN IS-CHEMAINUS-SAWMILL | 28-Jul-94 | 1500 m3 |
| | | VAN IS-CHEMAINUS-DRYSORT | 17-Aug-94 | 2500 m3 |
| | 3113 | VAN IS-LADYSMITH-DOMANS | 10-Aug-94 | 3900 m3 |
| | | VAN IS-DOMANS-DUKE PT | 21-Dec-94 | 1200 m3 |
| | | | **Total Dredge Quantity:** | 9100 m3 |
| | | | **Total Disposal Site Quantity:** | 9100 m3 |

# Disposal Site History Report

For Disposal Activities Between 01/01/94 and 31/12/94

**Disposal Site** Five Finger Island
**Number** 40
**Lattitude** 49°15.20
**Longitude** 123°54.60
**Depth (m)** 280

| Permit Type | Permit | Loadsite | Dump Start Date | Quantity |
|---|---|---|---|---|
| Dredge | 3099 | VAN IS-HARMAC | 17-Jul-94 | 1000 m3 |
| | 3113 | VAN IS-DOMANS-DUKE PT | 30-Jun-94 | 2900 m3 |
| | | | **Total Dredge Quantity:** | 3900 m3 |
| | | | **Total Disposal Site Quantity:** | 3900 m3 |

# Disposal Site History Report

For Disposal Activities Between 01/01/94 and 31/12/94

**Disposal Site** Malaspina Strait
**Number** 49
**Lattitude** 49°45.00
**Longitude** 124°27.00
**Depth (m)** 320

| Permit Type | Permit | Loadsite | Dump Start Date | Quantity |
|---|---|---|---|---|
| Dredge | 3077 | POWELL RIVER | 02-Jun-94 | 1400 m3 |
| | 3100 | STILLWATER | 22-May-94 | 2000 m3 |
| | | POWELL RIVER | 01-Jun-94 | 1000 m3 |
| | 3110 | POWELL RIVER | 06-Sep-94 | 10150 m3 |
| | | | **Total Dredge Quantity:** | 14550 m3 |
| | | | **Total Disposal Site Quantity:** | 14550 m3 |

# Disposal Site History Report

For Disposal Activities Between 01/01/94 and 31/12/94

**Disposal Site** Thornbrough Channel
**Number** 64
**Lattitude** 49°31.00
**Longitude** 123°28.30
**Depth (m)** 220

| Permit Type | Permit | Loadsite | Dump Start Date | Quantity |
|---|---|---|---|---|
| Dredge | 3108 | HOWE SD-TERMINAL FORESTS | 01-Nov-94 | 3500 m3 |
| | | | **Total Dredge Quantity:** | 3500 m3 |
| | | | **Total Disposal Site Quantity:** | 3500 m3 |

# Disposal Site History Report

For Disposal Activities Between 01/01/94 and 31/12/94

**Disposal Site** Watts Point
**Number** 65
**Lattitude** 49°38.50
**Longitude** 123°14.00
**Depth (m)** 230

| Permit Type | Permit | Loadsite | Dump Start Date | Quantity |
|---|---|---|---|---|
| Dredge | 3108 | HOWE SD-MAMQUAM | 11-Oct-94 | 3000 m3 |
| | | HOWE SD-WOODFIBRE | 25-Oct-94 | 4000 m3 |
| | | HOWE SD-EMPIRE LOGGING | 31-Oct-94 | 1500 m3 |
| | | | **Total Dredge Quantity:** | 8500 m3 |
| | | | **Total Disposal Site Quantity:** | 8500 m3 |

# Disposal Site History Report

For Disposal Activities Between 01/01/94 and 31/12/94

**Disposal Site** Kingcome Inlet
**Number** 75
**Lattitude** 50°55.00
**Longitude** 126°13.00
**Depth (m)** 125

| Permit Type | Permit | Loadsite | Dump Start Date | Quantity |
|---|---|---|---|---|
| Dredge | 3101 | KINGCOME INLET | 21-Jan-94 | 3800 m3 |
| | | | **Total Dredge Quantity:** | 3800 m3 |
| | | | **Total Disposal Site Quantity:** | 3800 m3 |

# Disposal Site History Report

For Disposal Activities Between 01/01/94 and 31/12/94

**Disposal Site** Cape Mudge
**Number** 116
**Lattitude** 49°57.70
**Longitude** 125°05.00
**Depth (m)** 200

| Permit Type | Permit | Loadsite | Dump Start Date | Quantity |
|---|---|---|---|---|
| Dredge | 3100 | VAN IS-MENZIES BAY-MB-WET SO | 23-Feb-94 | 3000 m3 |
| | | VAN IS-MENZIES BAY-MB-DRY SO | 01-Mar-94 | 3500 m3 |
| | 3121 | VAN IS-MENZIES BAY-MB-DRY SO | 30-Dec-94 | 1200 m3 |
| | | | **Total Dredge Quantity:** | 7700 m3 |
| | | | **Total Disposal Site Quantity:** | 7700 m3 |

# Disposal Site History Report

For Disposal Activities Between 01/01/94 and 31/12/94

**Disposal Site** Johnstone Strait-Hickey Point
**Number** 119
**Lattitude** 50°27.80
**Longitude** 126°04.80
**Depth (m)** 270

| Permit Type | Permit | Loadsite | Dump Start Date | Quantity |
|---|---|---|---|---|
| Dredge | 3101 | VAN IS-EVE RIVER | 20-Feb-94 | 2500 m3 |
| | | | **Total Dredge Quantity:** | 2500 m3 |
| | | | **Total Disposal Site Quantity:** | 2500 m3 |

# Disposal Site History Report

For Disposal Activities Between 01/01/94 and 31/12/94

**Disposal Site** Johnstone Strait-Hanson Island
**Number** 120
**Lattitude** 50°33.50
**Longitude** 126°48.00
**Depth (m)** 350

| Permit Type | Permit | Loadsite | Dump Start Date | Quantity |
|---|---|---|---|---|
| Dredge | 3101 | VAN IS-BEAVER COVE-CANFOR | 18-Jan-94 | 2500 m3 |
| | | VAN IS-PORT MCNEILL-WESTERN | 12-Feb-94 | 1500 m3 |
| | | GILFORD ISLAND-SCOTT COVE | 26-Feb-94 | 4000 m3 |
| | | VAN IS-BEAVER COVE-MOWATT | 04-Mar-94 | 500 m3 |
| | | | **Total Dredge Quantity:** | 8500 m3 |
| | | | **Total Disposal Site Quantity:** | 8500 m3 |

# Disposal Site History Report

For Disposal Activities Between 01/01/94 and 31/12/94

**Disposal Site** Roberts Bank - St of Georgia
**Number** 126
**Lattitude** 49°00.70
**Longitude** 123°10.50
**Depth (m)** 40

| Permit Type | Permit | Loadsite | Dump Start Date | Quantity |
|---|---|---|---|---|
| Dredge | 3092 | ROBERTS BANK | 25-May-94 | 222000 m3 |
| | | | **Total Dredge Quantity:** | 222000 m3 |
| | | | **Total Disposal Site Quantity:** | 222000 m3 |

# APPENDIX II

## Interim Contaminant Testing Guidelines For Ocean Disposal, Pacific and Yukon Region (1997 March)

# INTERIM CONTAMINANT TESTING GUIDELINES FOR OCEAN DISPOSAL PACIFIC AND YUKON REGION (1997 MARCH)

In response to growing concern over the biological implications of contaminants in marine sediments along the Canadian coastline, Environment Canada (EC), Pacific and Yukon Region (P&Y), in consultation with the Regional Ocean Disposal Advisory Committee (RODAC), has developed the following guidelines for sampling, analysis and reporting associated with proposed ocean disposal activities.

Under Schedule III, Part III of the Canadian Environmental Protection Act (CEPA), EC (P&Y) must consider the availability of practical alternative disposal options. To satisfy this requirement the applicant must provide a written record of the decision-making process used in selecting ocean disposal as the alternative of choice for disposal of materials. Disposal at sea is only permitted for materials where it is the environmentally preferable and practical alternative.

To assess the potential for environmental impacts of Ocean Disposal, EC (P&Y) will require chemical analyses to be performed on any material where there is a lack of chemical data, or a reason to believe that contaminants such as selected trace metals or organics are present. The minimum number of samples and the analyses required is specified in the following tables; the number of samples and the analyses required may be increased by EC (P&Y) in some instances. A proposed sampling program should be developed by the applicant, based on information provided in the following tables, and submitted to EC (P&Y) for approval prior to commencement of loading/ocean disposal activities.

Materials found to contain substances of concern at or higher than the regulated or guideline concentrations identified in the following tables may be considered for ocean disposal under section 71(3) of CEPA if they pass a series of biological tests. A tiered assessment approach using biological testing is used for this determination. The procedures for these tests are described in the document entitled "Interim Guidance for Application of Rapidly Rendered Harmless (RRH) and Trace Contaminants", which is available upon request from EC (P&Y). Ocean disposal options such as capping, containment, and side-casting, suggested by an applicant, will be considered by EC (P&Y), but their acceptance will be conditional on compliance with RRH protocols.

## SAMPLING AND ANALYSIS REQUIREMENTS

The following pages identify the minimum sampling and analytical requirements for dredged and excavated materials based on the size of the project, as well as rejection/screening limits currently used by EC (P&Y). Sampling requirements will be tailored on a site specific basis at the discretion of EC (P&Y), and analysis of other parameters may be requested when EC (P&Y) has reason to believe that other contaminants are present.

## MINIMUM REQUIREMENTS FOR DREDGED MATERIALS

SAMPLING REQUIREMENTS

All samples are analysed for minimum requirements.

| Project Quantity ($m^3$) | Permit Type | Minimum # of Samples | Type of Sampling |
|---|---|---|---|
| 0 - 4,000 | General * | 3 (1) ** | • surface sampling prior to loading |
| 0 - 10,000 | Site-Specific | 3 (1) | • surface sampling prior to loading |
| 10,000 - 30,000 | Site-Specific | 3 (1)<br>3 (1)<br>or 6 (2) | • surface sampling prior to loading<br>• sampling to depth prior to loading<br>• surface sampling prior to loading<br>• may require additional sampling during dredging |
| 30,000 - 60,000 | Site-Specific | 4 (2)<br>4 (2) | • surface sampling prior to loading<br>• sampling to depth prior to loading |
| >60,000 | Site-Specific | • sampling requirements to be determined on a project specific basis | |

* General Permits are multi-loadsite permits issued to applicants, and are specific to disposal from maintenance dredging projects of less than 4000 cubic metres.

** The brackets indicate the number of *composite* samples to be analysed initially for dioxins/furans, if requested by EC (P&Y).

MINIMUM ANALYSIS REQUIREMENTS

| | Parameter | Limit of Detection |
|---|---|---|
| **Trace Metals** | Mercury (Hg) | 0.2 µg/g |
| | Cadmium (Cd) | 0.2 µg/g |
| **Organics** | TPAH | 0.1 µg/g |
| **Other** | TOC | |
| | Particle Size | |

For PAH, the analytical methodology and quality assurance protocol must conform to that outlined in the 'Interim Quality Assurance Guidelines for Determination of Polynuclear Aromatic Hydrocarbons in Marine Sediments for Ocean Disposal', a copy of which is available from EC (P&Y).

Should the site history reveal cause for environmental concern, an increased number of samples and/or analysis of other metals and/or organics may be requested. Additional parameters may include the following:

| | Parameter | Limit of Detection |
|---|---|---|
| **Trace Metals** | Copper (Cu) | 10 µg/g |
| | Zinc (Zn) | 10 µg/g |
| | Arsenic (As) | 10 µg/g |
| | Chromium (Cr) | 10 µg/g |
| | Nickel (Ni) | 10 µg/g |
| | Lead (Pb) | 10 µg/g |
| **Organics** | PCB | 0.05 µg/g |
| | PCP | 0.05 µg/g |
| | Dioxins/furans | 10 pg/g for $T_4CDD$ |

The analysis results are to be reported on a dry weight basis with detection limits less than or equal to those stated above. The precision of the test method should be indicated by reporting analyses on five replicate sub-samples on 10% of the trace metal samples, and two replicate sub-samples on 20% of the organics samples, with a minimum of one replicated sample. Sub-sampling should be done following homogenizing but prior to digestion of the sample and the replicates should not be run consecutively. The accuracy of the test method should be indicated by reporting the results of certified reference materials analysed at the same time as the test samples.

For dioxin/furan, the analytical methodology and quality assurance protocol must conform to that outlined in the 'Internal Quality Assurance Requirements for Analysis of Dioxins in Environmental Samples', a copy of which is available from EC (P&Y).

## MINIMUM REQUIREMENTS FOR EXCAVATION MATERIALS*

* "General" Permits for excavation spoils are restricted to the loading and ocean disposal of *undisturbed, native material*. For other excavated materials, a site specific permit will be required.

SAMPLING REQUIREMENTS

| Project Quantity ($m^3$) | Minimum Number of Samples | Type of Sampling |
|---|---|---|
| 0 - 10,000 | 3 | • composite of surface native material to one metre depth |
| 10,000 - 30,000 | 6 | • composite of surface native material to one metre depth |
| 30,000 - 60,000 | 8 | • composite of surface native material to one metre depth |
| > 60,000 | sampling requirements to be determined on a project specific basis | |

MINIMUM ANALYSIS REQUIREMENTS

| | Parameter | Limit of Detection |
|---|---|---|
| **Trace Metals** | Mercury (Hg) | 0.2 µg/g |
| | Cadmium (Cd) | 0.2 µg/g |
| | Lead (Pb) | 10 µg/g |
| | Copper (Cu) | 10 µg/g |
| | Zinc (Zn) | 10 µg/g |
| | Arsenic (As) | 10 µg/g |
| | Chromium (Cr) | 10 µg/g |
| | Nickel (Ni) | 10 µg/g |
| **Organics** | TPAH | 0.1 µg/g |
| **Other** | TOC | |
| | Particle Size | |

Should the site history reveal cause for environmental concern, an increased number of samples and/or analysis of other metals and/or organics may be requested.

The analysis results are to be reported as stipulated under Table 1. Minimum requirements for dredged materials.

## REJECTION/SCREENING LIMITS

| Parameter | Rejection/Screening Limit (µg/g dry weight) |
|---|---|
| Cadmium | 0.6 µg/g |
| Mercury | 0.75 µg/g |
| Arsenic<br>Copper Zinc<br>Beryllium<br>Chromium<br>Nickel<br>Vanadium<br>Lead | * 0.1 % or more by weight or 1000 µg/g |
| Chlorophenols (PCP)<br>(penta and tetra isomers) | 1.0 µg/g |
| Polychlorinated biphenyls (PCB) | 0.1 µg/g |
| PAH (total) | 2.5 µg/g |
| Dioxin/Furan | "quantifiable" 2,3,7,8 TCDD |

* These levels are defined as "significant amounts" as agreed to by Canada as a signatory to the London Convention (LC); if exceeded, special care measures are required for disposal. *EC (P&Y) considers these levels as general guidelines only and may impose more stringent limits.*

## STEPS REQUIRED FOR COLLECTING SAMPLES AND SUBMITTING ANALYTICAL DATA

Prepare the following information:

1) a location map for the dredge/excavation site with the the street address of the proposed excavation or dredge site,
2) a site map showing the proposed excavation or dredge site relative to known landmarks and/or streets,
3) a list of any known possible contaminant input sources in the vicinity of the proposed works,
4) a written record of the decision making process used in selecting ocean disposal as the preferred materials disposal option, explaining why other disposal methods are not being used,
5) a site use history for the site from which the material destined for ocean disposal will originate, and
6) a proposed sampling plan of the site showing the proposed sampling locations, and a list of proposed analyses. The proposed sampling plan should be developed based on information presented in this document. Assistance in designing a sampling program can be provided by Environment Canada (EC), Pacific and Yukon Region (P&Y). *The sampling program must be approved prior to taking the samples.*

The information identified above should be sent to EC (P&Y). If the project does not qualify for completion under the terms and conditions of a "General" permit, this information should be submitted with a completed Ocean Disposal Application form. For information on how to apply, please contact EC (P&Y).

If the project qualifies for completion under a "General" Ocean Disposal Permit, this information must be submitted to EC (P&Y) with a covering letter describing the proposed activities in detail, and the proposed schedule for the work. Upon completion of the sampling and analyses program, the test data, together with all QA/QC data as identified in the foregoing information, must be sent to EC (P&Y).

No work may proceed under a "General" Permit until written approval for the specific site has been received from EC (P&Y), and a copy of the approval letter is posted at the work site.

For further information on this document, or any other matter relating to Ocean Disposal, please contact the following:


| | |
|---|---|
| Dixie Sullivan | (604) 666-2730 |
| Duane Brothers | (604) 666-0724 |
| Cathy Schnider | (604) 666-2685 |

# GENERAL GUIDE TO SOIL AND SEDIMENT SAMPLE COLLECTION

Containers for the samples should be obtained from the laboratory contracted to conduct the required analyses. Avoid unnecessary contact with clean glassware and utensils. A clean stainless steel or teflon spoon or scoop is ideal for transferring samples. Handle containers by the outsides only. Do not touch the inside of the jar, or teflon (or foil) liners, and use spoons or scoops by the handles only. When removing a foil or teflon liner and lid from a jar, remove as one piece and put down on a piece of foil or other clean surface while filling the jar.

If using a grab sampler, remove the water from the surface of the grab, taking care not to disturb the contents if possible. Use the clean scoop to remove a portion of the sediment from the middle of the sampler down to the depth of the material caught in the grab. The material in the sample jar should be representative of the material to be loaded for ocean disposal.

Alternatively, the sample may be taken by removing the lid, holding the jar by the sides and scooping the sample from the sediment without the use of other utensils. The threads of the jar may then be wiped with a paper towel before replacing the lid. Do not fill the jar more than about 3/4 full, allowing plenty of room for mixing/stirring, and expansion during freezing.

When the sample is in the jar, replace the teflon/foil liner and lid, and label the jar with project identification, the sampling site number, and the date.

To clean the sampling spoon or grab in-between samples, wipe with a paper towel to remove any solids, then rinse with water. Clean the tray in this manner as required.

If three samples are required for analysis, three small jars of sediment should be taken for *each* sampling station, for a total of nine jars. The three jars per sample will be composited by the analytical lab by taking equal aliquots of sample from each jar for a single analysis of most parameters of concern. The samples may be further composited for other testing as required but would otherwise be maintained as discrete samples.

Keep the samples in a refrigerator or on ice for short term storage (1-2 days); freeze the sample as soon as possible or store over dry ice for long term storage. The laboratory responsible for the analyses should be asked to freeze the samples after removal of sufficient material to complete the required analyses. These samples should remain frozen until the permit, or approval under a general permit, has been issued by EC (P&Y).

# APPENDIX III

## Benthic Community Analysis for Cape Mudge and Malaspina Strait Disposal Sites (June 1994)

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# 1.0 PROJECT SUMMARY - CAPE MUDGE AND MALASPINA OCEAN DISPOSAL SITES

## 1.1 Scope of Work

EVS Consultants provided taxonomic processing and data analysis for marine benthic samples from the Cape Mudge and Malaspina ocean disposal sites as part of the 1994 ocean disposal monitoring program for Environment Canada. Two reference areas, Halibut Ref. 2 (HAL.2) and Pender Harbour (PEN.) were also sampled as control sites.

The scope of work consisted of the following laboratory and data analysis services:

- sorting and enumeration of organisms from 34 marine benthic samples
- taxonomic identification to lowest practical taxonomic level (usually species)
- data analysis including species richness and total abundance
- statistical analysis including Principal Components Analysis
- QA/QC including 95% sorting efficiency, 20% resort of each sample, external verification of 5% of taxonomic identifications, and 100% verification of the final data set.

# 2.0 BENTHIC SAMPLE PROCESSING

## 2.1 Sample Inventory

The benthic samples were received by EVS Consultants on January 5, 1995. Upon arrival at the EVS benthic laboratory, all benthic samples were reinventoried and checked against chain-of-custody forms. If a sample consisted of multiple containers, all containers were located and processed as a group. The samples arrived intact and all 34 samples were accounted for.

Sample rescreening was performed by Environment Canada prior to shipment of samples to EVS. The molluscs showed evidence of significant shell erosion, possibly due to extended exposure to formalin prior to transfer to 70% ethanol. The samples received by the EVS benthic laboratory were preserved in 70% ethanol as specified in the contract.

## 2.2 Benthic Sorting

Standard and accepted techniques were used for sorting organisms from the sediments. Small fractions of a sample were placed in a petri dish under a 10 power magnification dissecting microscope. The petri dish was scanned systematically and all animals and fragments were removed

using forceps. Each petri dish was sorted at least twice to ensure removal of all animals. Each organism was removed and placed in 70% ethanol in one of the following major taxonomic groups:

Polychaeta
Arthropoda
Mollusca
Miscellaneous taxa (Echinodermata, Nemertea, Sipuncula, etc.).

### 2.3 Taxonomy

All organisms were counted and identified to the lowest practical taxonomic level, generally species. If animal fragments were present, only anterior portions were counted. Identifications were performed by regional taxonomic experts using stereo dissecting and high-power compound microscopes.

## 3.0 QUALITY ASSURANCE/CONTROL PROCEDURES AND RESULTS

### 3.1 Quality Assurance Procedures

The following quality assurance and control (QA/QC) procedures for both sorting and taxonomy were rigorously followed. Twenty percent of each processed sample was resorted to check sorting efficiency and accuracy. The only exceptions to this were the reference samples (Hal. 2 and PEN) which contained low volumes of sediment. To ensure maximum reliability in the resort procedure, 100 percent of the Hal. 2 sample and 50 percent of the PEN. sample was resorted. Sorting QA/QC was done using 25 power magnification by someone other than the original sorter. A sample passed if the number of organisms found during the QA/QC check did not represent more than 5 percent of the total number of organisms found in the entire sample. If the number of organisms found was greater than 5 percent of the total number, the entire sample was resorted.

Taxonomic QA/QC was achieved by sending 5 percent of the samples from each major taxonomic group out for independent reidentification by a qualified regional expert.

### 3.2 Sorting QA/QC Results

The 20 percent QA/QC resort procedure found less than five percent of organisms in each sample. The percent of organisms missed during initial sorting ranged from 0 to 3.3 percent. In all cases, the samples passed the 95 percent sorting efficiency criterion specified for this project. These results are presented in Appendix A.

### 3.3 Taxonomy QA/QC Results

#### 3.3.1 Polychaeta

The polychaete taxonomic QA/QC was in good agreement with the initial identifications. No significant differences were noted.

### 3.3.2 Arthropoda

The arthropod taxonomic QA/QC was in good agreement with the initial identifications with the following exception:

| Original I.D. | QA/QC I.D. |
|---|---|
| *Heterophoxus oculatus* | *Harpiniopsis fulgens* |

The above QA/QC change for Arthropoda occurred due to the poor condition of these particular organisms. This QA change has been incorporated into the final data set.

### 3.3.3 Mollusca

No significant differences were found in the taxonomic QA/QC for Mollusca.

### 3.3.4 Miscellaneous Taxa

No significant differences were found in the taxonomic QA/QC for Miscellaneous taxa.

A list of taxonomic references used during the taxonomic phase of this project is included in Appendix B.

## 4.0 BENTHIC INFAUNA DATA

The following station identifications were used in the benthic infauna data set. Stations from the Cape Mudge site were designated as CM; therefore Cape Mudge stations 1 through 9 were named CM1, CM2, ...CM9, respectively. Similarly, the Malaspina stations were named MAL1, MAL2, ...MAL9.

The last column in the benthic infauna data set (column V) lists abundance totals for each taxon listed in column A. The last value in column V is the total number of organisms in the data set. The letter P for certain miscellaneous taxa indicates that a colonial organism was present.

## 5.0 PRELIMINARY BENTHIC COMMUNITY STATISTICS

EVS Consultants prepared a macroinvertebrate taxa abundance by station data matrix from samples collected from the Cape Mudge and Malaspina ocean disposal sites. Because the replicate grab samples were composited for each station, the planned hypothesis-testing statistical technique (t-tests and ANOVA) could not be conducted. To maximize the utility of the information provided in this report, a multivariate statistical technique, Principal Components Analysis (PCA), was conducted on the data set to explore community structure.

## 5.1 Methods

Data from a total of 20 stations (Cape Mudge - 9 stations; Malaspina Strait - 9 stations; Pender Harbour reference station; Halibut Harbour reference station) were tabulated into a benthic macroinvertebrate taxa abundance by station matrix for analysis with SYSTAT (SYSTAT, 1992). Summary statistics for total abundance, species richness, and major taxa abundance were calculated for each sampling station and averaged for each disposal site.

PCA was used to determine patterns of intercorrelations among the dominant taxa across stations (see Tabachnik and Fidell, 1983, for more details on PCA). Dominant taxa were defined as those present at 75 percent or more of the stations. PCA calculates a few key "principal" components (PC) that serve to reduce the multidimensionality of the data. The orthogonal (i.e., unrelated) components can reveal coherent and independent subgroups of stations within the data set. Each species variable used in the PCA has a "loading" for each principal component that represents the correlation between that variable and the component. A positive loading indicates a positive correlation (i.e., abundance of that particular species increases with higher values of the principal component); a negative loading indicates a negative correlation (i.e., the abundance of that particular species decreases with increasing values of the principal component). Each station receives a "score" for each component based on the benthic community composition present at the station.

A biplot ordination diagram (first component [PC1] on x-axis; second component [PC2] on y-axis) was used to graphically summarize the PCA results (see Figure 1). Station PC scores and species loadings were transformed to a common scale before being plotted on the biplot. This process allows the simultaneous examination of station community composition in relation to each species. Similar to cluster analysis, the proximity of one station to another is an indication of station similarity. Furthermore, the importance of particular species at a station is indicated by the proximity of that station to the head of the that species' vector.

## 5.2 Summary Statistics

Summary statistics results are provided in Table 1. Benthic macroinvertebrates at the Cape Mudge ocean disposal site were generally more abundant and diverse than at the Halibut Harbour reference station. Abundance and diversity were relatively similar at the Malaspina Strait disposal site and the Pender Harbour reference site.

## 5.3 Principal Components Analysis

Loadings of dominant species on the two main principal components (PC1 and PC2) are presented in Table 2. Strong loaders (i.e., absolute value of loading >0.750) onto PC1 included the polychaete *Aricidea neosuecica* and bivalves. Moderate loaders (i.e., absolute value of loading = 0.300 to 0.750) onto PC1 included polychaetes *Exogone lourei* and *Nephtys cornuta*. Only the arthropod *Harpiniopsis fulgens* loaded strongly onto PC2. Polychaetes *E. lourei* and *N. cornuta* loaded moderately in a positive direction on PC2. The polychaete *A. neosuecica* loaded moderately in a negative direction on PC2.

The PCA biplot (using PC1 and PC2 [Figure 1]) shows two distinct station groupings. The right side of the plot contains primarily stations from the Cape Mudge disposal site, while the left quadrant contains most of the Malaspina disposal site stations and the two reference stations. The two groupings vary mostly in their scores on PC1. The positioning of the Cape Mudge disposal site stations relative to the bivalve and *Aricidea neosuecica* vectors suggest that these taxa are more prevalent at Cape Mudge compared to the Malaspina disposal site and the two reference stations. The relative similarity between the disposal sites and their respective reference stations can be seen on the biplot. The Cape Mudge stations are grouped away from the Halibut Harbour station, which implies that differences between the disposal and reference site exist. The summary statistics support this conclusion, with Halibut Harbour containing a less abundant and rich benthic community than that found at the Cape Mudge disposal site. The Pender Harbour station, however, is situated amongst the Malaspina disposal site stations, which indicates that the two areas have relatively similar benthic communities.

Table 1. Summary statistics for Cape Mudge and Malaspina Strait ocean disposal sites and Pender Harbour and Halibut Harbour reference sites.

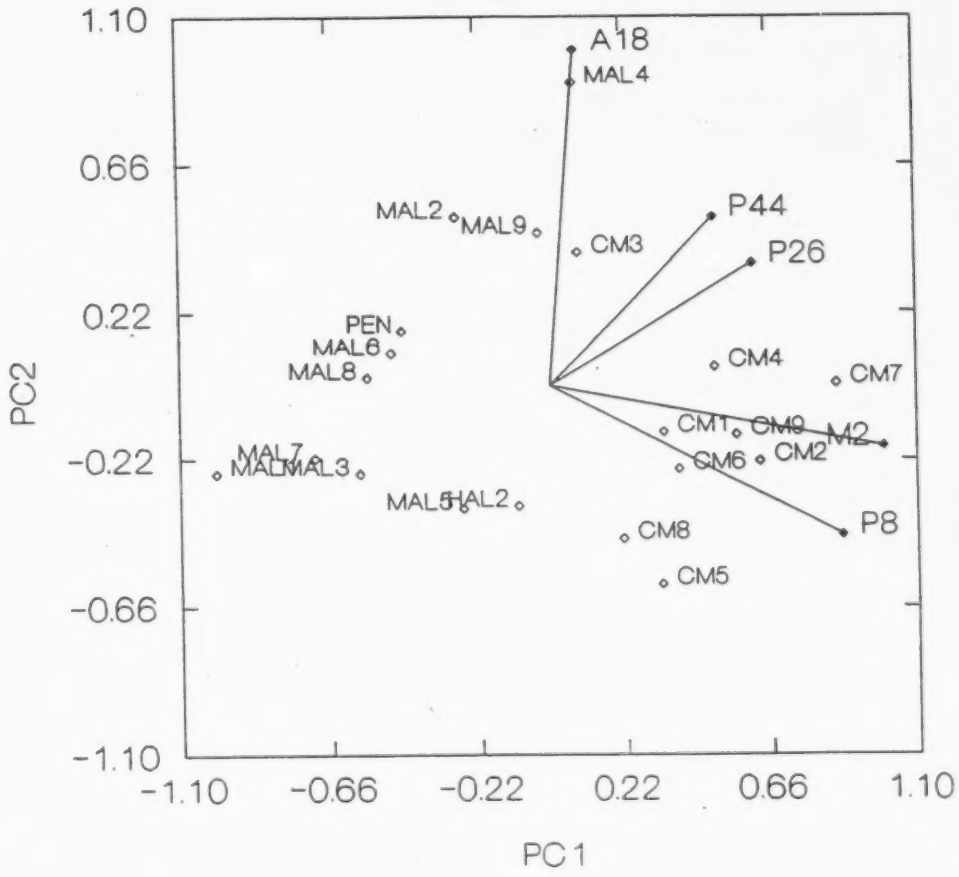
| STATION | Total Abundance | Species Richness | Polychaete Abundance | Arthropod Abundance | Mollusk Abundance | Misc. Taxa Abundance |
|---|---|---|---|---|---|---|
| CM1 | 383 | 67 | 186 | 70 | 35 | 92 |
| CM2 | 319 | 69 | 135 | 31 | 89 | 64 |
| CM3 | 143 | 45 | 78 | 17 | 22 | 26 |
| CM4 | 333 | 59 | 109 | 46 | 32 | 146 |
| CM5 | 316 | 63 | 137 | 30 | 68 | 81 |
| CM6 | 378 | 67 | 174 | 34 | 46 | 124 |
| CM7 | 450 | 70 | 268 | 62 | 64 | 56 |
| CM8 | 307 | 57 | 132 | 25 | 66 | 84 |
| CM9 | 351 | 69 | 165 | 24 | 37 | 125 |
| | | | | | | |
| Cape Mudge Mean | 331 | 63 | 154 | 38 | 51 | 89 |
| | | | | | | |
| MAL1 | 20 | 17 | 11 | 3 | 4 | 2 |
| MAL2 | 54 | 27 | 29 | 9 | 10 | 6 |
| MAL3 | 36 | 22 | 24 | 3 | 6 | 3 |
| MAL4 | 121 | 42 | 68 | 28 | 17 | 8 |
| MAL5 | 226 | 46 | 123 | 71 | 19 | 13 |
| MAL6 | 45 | 26 | 31 | 5 | 7 | 2 |
| MAL7 | 27 | 22 | 13 | 5 | 6 | 3 |
| MAL8 | 41 | 24 | 18 | 5 | 11 | 7 |
| MAL9 | 153 | 31 | 88 | 42 | 12 | 11 |
| | | | | | | |
| Malaspina Mean | 80 | 29 | 45 | 19 | 10 | 6 |
| | | | | | | |
| Halibut Harbour | 79 | 24 | 42 | 3 | 10 | 24 |
| | | | | | | |
| Pender Harbour | 55 | 31 | 37 | 5 | 4 | 9 |

Table 2. Species loadings on the two main principal components analysis of dominant taxa across all stations.

| Species (species identification code) | Principal Components | |
|---|---|---|
| | PC1 (38.4%)* | PC2 (27.6%)* |
| *Exogone lourei* (P26) | 0.550 | 0.355 |
| *Nephtys cornuta* (P44) | 0.447 | 0.462 |
| *Aricidea neosuecica* (P8) | 0.783 | -0.411 |
| *Harpiniopsis fulgens* (A18) | 0.075 | 0.920 |
| Bivalvia (M2) | 0.895 | -0.166 |

* Percent variation explained by the principal component

Figure 1. PCA biplot using the two main principal components (i.e., PC1 and PC2).




| Figure Legend | | | | | |
|---|---|---|---|---|---|
| Code | P26 | P44 | P8 | A18 | M2 |
| Taxa | *Exogone lourei* | *Nephtys cornuta* | *Aricidea neosuecica* | *Harpiniopsis fulgens* | Bivalvia |

## 5.4 Summary of Statistical Results

The results of both the summary statistics and the PCA suggest that the benthic macroinvertebrate community at the Cape Mudge disposal site is different from those found at the Malaspina disposal site and the Pender Harbour and Halibut Harbour reference sites. Comparisons between disposal sites and reference areas showed that benthic macroinvertebrates at the Cape Mudge disposal site were more abndant and diverse than at Halibut Harbour, while there were no striking differences between the Malaspina Strait disposal site and the Pender Harbour site.

## 5.5 Recommendations

Additional statistical analyses (outside the scope of the present contract) are recommended in order to understand the factors influencing benthic community structure at the disposal and reference sites. Much insight can be gained by a synoptic (i.e., refering to different samples collected at the same station for various analyses) approach using multivariate statistics to link benthic community structure and various physical and chemical variables (e.g., depth, grain size, organic carbon, metals, organic compounds). Such analyses could provide some indication of the relative influence of ocean disposal activities and natural factors on benthic community structure.

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## APPENDIX A

### 20% Sorting QA/QC Log

| | Sample I.D. | Sorter | Sorted Vol.(ml) | QA/QC Vol.(ml) | Total#QA Organisms* | Total Abund. | % Sorting Efficiency | P/F | Comments |
|---|---|---|---|---|---|---|---|---|---|
| 1 | CM1 | CR | 1000 | 200 | 0 | 383 | 100 | P | 0 QAOrganisms |
| 2 | CM2 | DS | 800 | 160 | 0 | 319 | 100 | P | 0 QAOrganisms |
| 3 | CM3 | AC | 650 | 130 | 0 | 143 | 100 | P | 0 QAOrganisms |
| 4 | CM4 | AC | 1175 | 235 | 0 | 333 | 100 | P | 0 QAOrganisms |
| 5 | CM5 | DS | 1020 | 204 | 0 | 316 | 100 | P | 0 QAOrganisms |
| 6 | CM6 | AC | 700 | 140 | 5P | 378 | 98.7 | P | |
| 7 | CM7 | CR | 1350 | 270 | 0 | 450 | 100 | P | 0 QAOrganisms |
| 8 | CM8 | DS | 750 | 150 | 5P | 307 | 98.4 | P | |
| 9 | CM9 | DS | 875 | 175 | 5P | 351 | 98.6 | P | |
| 10 | MAL1 | CR | 175 | 35 | 0 | 20 | 100 | P | 0 QAOrganisms |
| 11 | MAL2 | AC | 1450 | 290 | 0 | 54 | 100 | P | 0 QAOrganisms |
| 12 | MAL3 | DS | 300 | 60 | 0 | 36 | 100 | P | 0 QAOrganisms |
| 13 | MAL4 | AC | 1175 | 235 | 0 | 121 | 100 | P | 0 QAOrganisms |
| 14 | MAL5 | DS | 1150 | 230 | 0 | 226 | 100 | P | 0 QAOrganisms |
| 15 | MAL6 | CR | 800 | 160 | 0 | 45 | 100 | P | 0 QAOrganisms |
| 16 | MAL7 | AC | 425 | 85 | 0 | 27 | 100 | P | 0 QAOrganisms |
| 17 | MAL8 | DS | 600 | 120 | 0 | 41 | 100 | P | 0 QAOrganisms |
| 18 | MAL9 | CR | 1550 | 310 | 5P | 153 | 96.7 | P | |
| 19 | HAL.2 | CR | 25 | 25 | 0 | 79 | 100 | P | 0 QAOrganisms |
| 20 | PEN. | CR | 50 | 25 | 0 | 55 | 100 | P | 0 QAOrganisms |

* P = Polychaeta
A= Arthropoda
M = Mollusca
Ms. = Misc. taxa

## APPENDIX B

### REFERENCES USED IN THE IDENTIFICATION OF POLYCHAETA

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# APPENDIX C

## BENTHIC INFAUNA DATA

| | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Cape Mudge/Malaspina Strait | CM1 | CM2 | CM3 | CM4 | CM5 | CM6 | CM7 | CM8 | CM9 |
| 2 | **POLYCHAETA** | | | | | | | | | |
| 3 | Amage anops | | | | | | | | | 1 |
| 4 | Ampharete finmarchica | 1 | | | | | | | | |
| 5 | Ampharete spp. | 2 | 1 | | 3 | | 5 | | | 2 |
| 6 | Amphicteis spp. | | | | | | | | | |
| 7 | Ancistrosyllis groenlandica | 2 | 1 | 4 | 4 | 12 | 9 | 20 | 2 | 3 |
| 8 | Anobothrus gracilis | | 1 | | 1 | 1 | 1 | | 3 | 4 |
| 9 | Aricidea lopezi | | | | | | 3 | 8 | | 2 |
| 10 | Aricidea neosuecica | 45 | 28 | 10 | 24 | 34 | 27 | 39 | 22 | 35 |
| 11 | Aricidea ramosa | 13 | 14 | 1 | 1 | 3 | 5 | 6 | 2 | 6 |
| 12 | Aricidea spp. | 17 | 9 | 3 | 15 | 6 | 7 | 23 | 4 | 11 |
| 13 | Asclerocheilus beringianus | | 1 | | | | | | | |
| 14 | Asychis spp. | | | | | 1 | | | | |
| 15 | Brada sachalina | | | | | | | 2 | | |
| 16 | Capitella capitata complex | | 2 | | | | 1 | | | |
| 17 | Capitellidae | | 1 | | | 1 | | | | |
| 18 | Chaetopteridae | | | | | | | | | |
| 19 | Cirratulidae | 3 | 1 | 3 | 1 | | 3 | 5 | | |
| 20 | Cossura spp. | 3 | 6 | 8 | 4 | 4 | 7 | 29 | | 9 |
| 21 | Decamastus gracilis | 2 | 1 | | 3 | | | | | |
| 22 | Diopatra ornata | | | | | | | 1 | | |
| 23 | Dorvillea rudolphi | | | | | | | | | |
| 24 | Eteone longa | | 1 | | | | | | | |
| 25 | Euclymene cf. zonalis | | | | 1 | | | | | |
| 26 | Euclymene zonalis | | 3 | | | | | 3 | 1 | |
| 27 | Eunice valens | | | | | | | 1 | | |
| 28 | Exogone lourei | | 8 | 2 | 6 | 2 | 4 | 5 | 4 | 10 |
| 29 | Exogone spp. | 5 | | | | | | | | |
| 30 | Galathowenia oculata | 6 | 3 | 8 | 6 | 16 | 26 | 25 | 38 | 16 |
| 31 | Glycera nana | | | | | | | | | 1 |
| 32 | Glycinde armigera | | 1 | | | | | | | |
| 33 | Glycinde picta | | | | | | 1 | | | |
| 34 | Goniada annulata | | | 1 | | 2 | | | | |
| 35 | Goniada brunnea | 1 | | | | | | | 1 | |
| 36 | Gyptis brevipalpa | | | | | | 1 | 1 | 1 | 1 |
| 37 | Heteromastus spp. | | | | | | | | | |
| 38 | Levinsenia gracilis | 6 | 5 | 5 | | 2 | 3 | 6 | 2 | 7 |
| 39 | Levinsenia oculata | | | | | | | | | |
| 40 | Lumbrineridae | 3 | 8 | 10 | 4 | 8 | 13 | 15 | 5 | 12 |
| 41 | Maldane sarsi | | | | | | | 1 | | 1 |
| 42 | Maldane spp. | 5 | 1 | | | 1 | | 1 | 6 | 1 |
| 43 | Maldanidae | 14 | 7 | 1 | 4 | 2 | 9 | 10 | 10 | 2 |
| 44 | Mediomastus spp. | | | | | 2 | 4 | 2 | | 6 |
| 45 | Melinna cristata | | 1 | | 1 | | 1 | | | 1 |

| | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Cape Mudge/Malaspina Strait | CM1 | CM2 | CM3 | CM4 | CM5 | CM6 | CM7 | CM8 | CM9 |
| 46 | Nephtys cornuta | 14 | 4 | 9 | 6 | 1 | 2 | 19 | | 1 |
| 47 | Nephtys punctata | | | | | | 1 | | | |
| 48 | Nepthys ferruginea | 2 | 3 | 1 | 1 | 1 | | 1 | 2 | 1 |
| 49 | Nereis spp. | | | 1 | | | | | | |
| 50 | Nicomache lumbricalis | | | | | | 2 | 1 | 4 | |
| 51 | Notomastus spp. | | | | 3 | 9 | 1 | 4 | 1 | 2 |
| 52 | Notoproctus pacificus | 6 | | | | | | | | |
| 53 | Odontosyllis phosphorea | 4 | 1 | | 1 | 3 | 5 | 1 | | |
| 54 | Onuphis iridescens | 1 | 3 | 2 | 1 | 1 | 4 | 1 | 3 | 3 |
| 55 | Onuphis spp. | | | | | 4 | | | 1 | 1 |
| 56 | Ophelina acuminata | | | | | | | | | |
| 57 | Ophelina breviata | 8 | 2 | 1 | 4 | 4 | 3 | 8 | 2 | 2 |
| 58 | Ophelina groenlandica | | | | | | | | | |
| 59 | Orbinia felix | | | | | 1 | | | | |
| 60 | Owenia fusiformis | 5 | | 2 | | | | | | 2 |
| 61 | Pectinaria californiensis | | | | | | | | 1 | 1 |
| 62 | Pherusa plumosa | 4 | | | 1 | 3 | 3 | | | |
| 63 | Pholoe minuta | | 1 | | | 1 | | | | 1 |
| 64 | Pista bansei | | | | | | | | 1 | |
| 65 | Pista spp. | 1 | | | | | | | | |
| 66 | Polycirrus spp. | | 1 | | | | 2 | 4 | 1 | 5 |
| 67 | Polydora spp. | | | | | | | | | |
| 68 | Polynoidae | 2 | 2 | | | | 1 | | | 4 |
| 69 | Praxillella gracilis | | | | | 1 | | | | |
| 70 | Prionospio spp. | | 3 | 1 | 3 | | | 2 | | 1 |
| 71 | Scalibregma inflatum | 2 | | | 1 | | | | | |
| 72 | Scionella japonica | 3 | | | | | | | | |
| 73 | Scoloplos acmeceps | | | | | | | 3 | | |
| 74 | Sphaerodoropsis sphaerulifer | | | 1 | 2 | | | 1 | | |
| 75 | Spiochaetopterus costarum | | | | | 1 | | | | |
| 76 | Spionidae | | | | | | | | | |
| 77 | Spiophanes berkeleyorum | | | | | | 4 | 2 | | |
| 78 | Spiophanes kroyeri | | | | | | | | | |
| 79 | Spiophanes spp. | | | | 1 | 1 | | 1 | | |
| 80 | Sternaspis scutata | | 1 | 1 | | 1 | 4 | 2 | 3 | 4 |
| 81 | Syllis elongata | | 2 | | 3 | 5 | 6 | 13 | 11 | 6 |
| 82 | Syllis spongiphila | 1 | | | | | | | | |
| 83 | Syllis spp. | 4 | 3 | | 4 | 2 | 5 | | | |
| 84 | Terebellides stroemi | 1 | 4 | 1 | | | | | | |
| 85 | Travisia pupa | | | | | 1 | 1 | 2 | 1 | |
| 86 | Travisia spp. | | 1 | 2 | | | | | | |
| 87 | **ARTHROPODA** | CM1 | CM2 | CM3 | CM4 | CM5 | CM6 | CM7 | CM8 | CM9 |
| 88 | Ampelisca careyi | 1 | 3 | | | | | | | |
| 89 | Ampelisca spp. | 3 | 3 | 3 | 2 | | | 5 | | 2 |

| | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Cape Mudge/Malaspina Strait | CM1 | CM2 | CM3 | CM4 | CM5 | CM6 | CM7 | CM8 | CM9 |
| 90 | Ampelisca unsocalae | 9 | | | 9 | 5 | 13 | 15 | 8 | 4 |
| 91 | Aoroides spp. | 2 | | | | | | 1 | | |
| 92 | Bathyleberis spp. | | | 2 | | 1 | 1 | 1 | | |
| 93 | Campylaspis spp. | | 1 | | | | | | | |
| 94 | Conchoecia spp. | | | | | | | | | 1 |
| 95 | Copepoda | 9 | | | 1 | | | 2 | | |
| 96 | Cumella spp. | 1 | 1 | | 1 | | | | 1 | |
| 97 | Dexamonica reduncans | 3 | | | 2 | | | | | |
| 98 | Diastylis spp. | | | | 2 | | | 1 | | |
| 99 | Dyopedos spp. | | | | | 1 | | 1 | | |
| 100 | Ericthonius spp. | | | | | | | 1 | 2 | |
| 101 | Eudorella pacifica | 5 | 8 | 3 | 11 | 9 | 10 | 20 | 4 | 4 |
| 102 | Eudorellopsis longirostris | | 1 | | | | | 1 | | |
| 103 | Euphilomedes carcharodonta | | 1 | | | 1 | | 1 | | |
| 104 | Gnathia spp. | 2 | | | 1 | | | | 1 | |
| 105 | Harpiniopsis fulgens | 3 | 1 | 8 | 2 | 1 | 2 | 2 | 1 | 2 |
| 106 | Hippomedon denticulatus | 2 | | | | | | 2 | 1 | |
| 107 | Leptognathia spp. | 12 | 2 | | 7 | 1 | 1 | 3 | | 2 |
| 108 | Liljeborgia cota | | | | | | | | 2 | |
| 109 | Limnoria spp. | 1 | | | | | | | | 1 |
| 110 | Lysianassidae | | | | 1 | | | | | |
| 111 | Metaphoxus frequens | 3 | 5 | | 5 | 2 | 1 | | | 1 |
| 112 | Monoculodes spp. | | 1 | | | | | | | 2 |
| 113 | Munida spp. | | | | | | | | 1 | |
| 114 | Nebalia spp. | | | | | | | | | |
| 115 | Orchomene decipiens | | | | | 1 | | | 1 | 1 |
| 116 | Paraphoxus oculatus | | | | | | | | | |
| 117 | Photis spp. | 7 | 1 | | | 4 | | 2 | 1 | |
| 118 | Pleurogonium rubicundum | | 2 | 1 | | | 1 | 1 | | |
| 119 | Prachynella lodo | | | | 1 | | | | | |
| 120 | Rutiderma lomae | 4 | | | | | 3 | | | |
| 121 | Silophasma geminatum | | | | | 2 | 1 | | 2 | 1 |
| 122 | Stenothoidae | | | | | | | | | |
| 123 | Synchelidium shoemakeri | | | | 1 | 1 | | 3 | | 1 |
| 124 | Tanaidae | 3 | | | | 1 | 1 | | | 2 |
| 125 | Westwoodilla caecula | | 1 | | | | | | | |
| 126 | **MOLLUSCA** | CM1 | CM2 | CM3 | CM4 | CM5 | CM6 | CM7 | CM8 | CM9 |
| 127 | Adontorhina cyclia | 1 | 9 | 1 | 1 | | | | 9 | 2 |
| 128 | Bivalvia | 19 | 52 | 7 | 16 | 43 | 29 | 29 | 40 | 24 |
| 129 | Chaetoderma sp. 1 | 1 | 10 | 10 | 2 | 11 | 4 | 16 | 10 | 3 |
| 130 | Chaetoderma sp. 2 | | 1 | | 3 | | 1 | 6 | | 2 |
| 131 | Cidarina cidaris | | | | | | | | 1 | |
| 132 | Cylichna attonsa | | | | | | | | 1 | |
| 133 | Dentalium spp. | | | | | | | | 1 | |

| | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Cape Mudge/Malaspina Strait | CM1 | CM2 | CM3 | CM4 | CM5 | CM6 | CM7 | CM8 | CM9 |
| 134 | Gastropoda | 1 | 2 | | | | 4 | 1 | | |
| 135 | Lucinoma annulata | | | 1 | | | | | | |
| 136 | Macoma spp. | | | | | | | | | |
| 137 | Mytilidae | | 1 | 1 | | | | | | |
| 138 | Nucula tenuis | 1 | | | | | | | | |
| 139 | Nuculanidae | | | 1 | | | | 1 | | |
| 140 | Odontogena borealis | 4 | 3 | | 3 | 6 | 3 | 8 | 1 | 1 |
| 141 | Pectinidae | | | | | 1 | | | | |
| 142 | Scaphopoda | | | 1 | 2 | 5 | 3 | 2 | | 1 |
| 143 | Scintillona bellerophon | | | | | | | | | 2 |
| 144 | Solemya reidi | 7 | 10 | | 4 | 2 | 2 | 1 | 2 | 2 |
| 145 | Tellina spp. | | | | | | | | 1 | |
| 146 | Thyasira gouldii | | | | | | | | | |
| 147 | Turridae | | | | 1 | | | | | |
| 148 | **MISC. TAXA** | CM1 | CM2 | CM3 | CM4 | CM5 | CM6 | CM7 | CM8 | CM9 |
| 149 | Amphiodia spp. | | | | | | | | | 1 |
| 150 | Amphipholis squamata | | | | | | 2 | 1 | 1 | 1 |
| 151 | Apodida | 1 | | | | | | | 2 | |
| 152 | Brisaster latifrons | | | | | | 1 | | | |
| 153 | Campanulariidae | P | | | | | | | | |
| 154 | Chiridota spp. | | 1 | 2 | | 1 | 2 | | | 4 |
| 155 | Demospongiae | | | | | | | | | |
| 156 | Golfingia minuta | 17 | 30 | 12 | 91 | 48 | 86 | 22 | 52 | 88 |
| 157 | Golfingia pugettensis | 3 | | | | 1 | 1 | | | 5 |
| 158 | Golfingia spp. | | 1 | | | | | | | |
| 159 | Leptoplanidae | | | | | | | | | 2 |
| 160 | Lineidae | | | | | | 1 | | | |
| 161 | Micrura spp. | | | | 1 | 1 | 3 | 2 | | |
| 162 | Molpadia intermedia | | | | | | | | | |
| 163 | Nematoda | 56 | 19 | 1 | 36 | 17 | 8 | 27 | 15 | 7 |
| 164 | Ophiura leptoctenia | | 3 | 6 | 9 | 4 | 10 | | 10 | 12 |
| 165 | Ophiura spp. | | 3 | 2 | 6 | 3 | 2 | | 3 | 2 |
| 166 | Ophiurida | | 7 | 1 | 3 | 6 | 4 | 3 | 1 | 2 |
| 167 | Ophiuroidea | 12 | | | | | | | | |
| 168 | Paranemertes spp. | | | | | | | | | 1 |
| 169 | Sertularia spp. | P | | | | | P | | | |
| 170 | Tubulanus polymorphus | | | 2 | | | 3 | 1 | | |
| 171 | Tubulanus spp. | 1 | | | | | | | | |
| 172 | | | | | | | | | | |
| 173 | ABUN BY REPLICATE | 383 | 319 | 143 | 333 | 316 | 378 | 450 | 307 | 351 |

| | A | K | L | M | N | O | P | Q | R | S |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Cape Mudge/Malaspina Strait | MAL1 | MAL2 | MAL3 | MAL4 | MAL5 | MAL6 | MAL7 | MAL8 | MAL9 |
| 2 | **POLYCHAETA** | | | | | | | | | |
| 3 | Amage anops | | | 1 | | | | | | |
| 4 | Ampharete finmarchica | | | | | | | | | |
| 5 | Ampharete spp. | | | | | | | | | |
| 6 | Amphicteis spp. | | | | | 1 | | | | |
| 7 | Ancistrosyllis groenlandica | | 1 | 2 | | | | 1 | | |
| 8 | Anobothrus gracilis | | | | | 1 | | | | |
| 9 | Aricidea lopezi | | 6 | 3 | 4 | 18 | 5 | 1 | | 7 |
| 10 | Aricidea neosuecica | 4 | 5 | 9 | 2 | 8 | 5 | 2 | | 5 |
| 11 | Aricidea ramosa | | | | | | | | | |
| 12 | Aricidea spp. | | | | 6 | | 1 | | | |
| 13 | Asclerocheilus beringianus | | | | | | | | | |
| 14 | Asychis spp. | | | | | | | | | |
| 15 | Brada sachalina | | | | | | | | | |
| 16 | Capitella capitata complex | | | | | | | | | |
| 17 | Capitellidae | | | | | | | | | |
| 18 | Chaetopteridae | | | | | | | | 1 | |
| 19 | Cirratulidae | | | | 1 | 2 | | | | |
| 20 | Cossura spp. | | 1 | 2 | | | 4 | | 3 | 3 |
| 21 | Decamastus gracilis | | | | | | | | | |
| 22 | Diopatra ornata | | | | | | | | | |
| 23 | Dorvillea rudolphi | | | | 2 | | | | 3 | 4 |
| 24 | Eteone longa | | | | | | | | | |
| 25 | Euclymene cf. zonalis | | | | | | | | | |
| 26 | Euclymene zonalis | | | | | | | | | |
| 27 | Eunice valens | | | | | | | | | |
| 28 | Exogone lourei | | 1 | | 13 | 6 | 2 | | 1 | 24 |
| 29 | Exogone spp. | | | | | | | | | |
| 30 | Galathowenia oculata | | | | | | | | | |
| 31 | Glycera nana | | | | | 1 | | | | |
| 32 | Glycinde armigera | | | | | | | | | |
| 33 | Glycinde picta | | | | | | | | | |
| 34 | Goniada annulata | 1 | | 1 | | | | | | |
| 35 | Goniada brunnea | | | | | | | | | |
| 36 | Gyptis brevipalpa | | | | 2 | 5 | 1 | | | 2 |
| 37 | Heteromastus spp. | | | | | | | | | |
| 38 | Levinsenia gracilis | 1 | | | 8 | | 2 | | 3 | 1 |
| 39 | Levinsenia oculata | | | | | | | 2 | | |
| 40 | Lumbrineridae | 1 | | | 5 | | | 1 | | |
| 41 | Maldane sarsi | | | | 1 | | | | | |
| 42 | Maldane spp. | 1 | 1 | | | | | | | |
| 43 | Maldanidae | | | | | | | | | |
| 44 | Mediomastus spp. | | | | 6 | 31 | 2 | | 1 | 8 |
| 45 | Melinna cristata | | 1 | | 1 | | | | 1 | |

| | A | K | L | M | N | O | P | Q | R | S |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Cape Mudge/Malaspina Strait | MAL1 | MAL2 | MAL3 | MAL4 | MAL5 | MAL6 | MAL7 | MAL8 | MAL9 |
| 46 | Nephtys cornuta | | 5 | 1 | 6 | 3 | 1 | 3 | 2 | 1 |
| 47 | Nephtys punctata | | | | 1 | | 1 | 1 | | 1 |
| 48 | Nepthys ferruginea | | | | | | | | | |
| 49 | Nereis spp. | | | | 1 | 2 | | | | 2 |
| 50 | Nicomache lumbricalis | | | | | | | | | |
| 51 | Notomastus spp. | | | | | | | | | |
| 52 | Notoproctus pacificus | | | | | | | | | |
| 53 | Odontosyllis phosphorea | | | | | | | | | |
| 54 | Onuphis iridescens | 1 | | | | | | | | |
| 55 | Onuphis spp. | | | | | | | | | |
| 56 | Ophelina acuminata | | | | | | | | | 1 |
| 57 | Ophelina breviata | | | | 1 | | | | | |
| 58 | Ophelina groenlandica | | | | | | | 1 | | |
| 59 | Orbinia felix | | | | | | | | | |
| 60 | Owenia fusiformis | | | | | | | | | |
| 61 | Pectinaria californiensis | 1 | | | 3 | 1 | 1 | | | |
| 62 | Pherusa plumosa | | | | | | | | | |
| 63 | Pholoe minuta | | | | | | | | | |
| 64 | Pista bansei | | | | | | | | | |
| 65 | Pista spp. | | | | | | | | | |
| 66 | Polycirrus spp. | | | | | | | | | |
| 67 | Polydora spp. | | | | | 1 | | | | |
| 68 | Polynoidae | | | | 1 | 16 | | | 1 | 3 |
| 69 | Praxillella gracilis | | | | | | | | | |
| 70 | Prionospio spp. | 1 | | | 1 | 5 | | | | |
| 71 | Scalibregma inflatum | | | | | | | | | |
| 72 | Scionella japonica | | | | | | | | | |
| 73 | Scoloplos acmeceps | | | | | | | | | |
| 74 | Sphaerodoropsis sphaerulifer | | | | | | | | | |
| 75 | Spiochaetopterus costarum | | | | | | | | | |
| 76 | Spionidae | | 2 | 2 | 1 | 8 | 3 | | 1 | 26 |
| 77 | Spiophanes berkeleyorum | | 4 | 2 | 2 | 5 | 1 | | 1 | |
| 78 | Spiophanes kroyeri | | | | | | | 1 | | |
| 79 | Spiophanes spp. | | | | | | | | | |
| 80 | Sternaspis scutata | | 1 | | | | | | | |
| 81 | Syllis elongata | | 1 | 1 | | | 2 | | | |
| 82 | Syllis spongiphila | | | | | 5 | | | | |
| 83 | Syllis spp. | | | | | 3 | | | | |
| 84 | Terebellides stroemi | | | | | 1 | | | | |
| 85 | Travisia pupa | | | | | | | | | |
| 86 | Travisia spp. | | | | | | | | | |
| 87 | **ARTHROPODA** | MAL1 | MAL2 | MAL3 | MAL4 | MAL5 | MAL6 | MAL7 | MAL8 | MAL9 |
| 88 | Ampelisca careyi | | | | | | | | | |
| 89 | Ampelisca spp. | | | | | | | | | |

| | A | K | L | M | N | O | P | Q | R | S |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Cape Mudge/Malaspina Strait | MAL1 | MAL2 | MAL3 | MAL4 | MAL5 | MAL6 | MAL7 | MAL8 | MAL9 |
| 90 | Ampelisca unsocalae | | | | | | | 1 | | |
| 91 | Aoroides spp. | | | | | | | | | |
| 92 | Bathyleberis spp. | | | | | | | | | |
| 93 | Campylaspis spp. | | | | | | | | | |
| 94 | Conchoecia spp. | | | | | | | | | |
| 95 | Copepoda | | 1 | | | 13 | | | 3 | 7 |
| 96 | Cumella spp. | | | | | | | | | |
| 97 | Dexamonica reduncans | | | | | | | | | |
| 98 | Diastylis spp. | | | | | | | | | |
| 99 | Dyopedos spp. | | | | | | | | | |
| 100 | Ericthonius spp. | | | | | | | | | |
| 101 | Eudorella pacifica | | | | 2 | | | | | 1 |
| 102 | Eudorellopsis longirostris | | | | | | | | | |
| 103 | Euphilomedes carcharodonta | | | | | | | 2 | | |
| 104 | Gnathia spp. | | | | | | | | | |
| 105 | Harpiniopsis fulgens | 1 | 7 | 2 | 17 | | 3 | 1 | 1 | 6 |
| 106 | Hippomedon denticulatus | | | | | | | | | |
| 107 | Leptognathia spp. | 2 | 1 | | 3 | 11 | 2 | 1 | 1 | |
| 108 | Liljeborgia cota | | | | | | | | | |
| 109 | Limnoria spp. | | | | 4 | 23 | | | | 27 |
| 110 | Lysianassidae | | | | 1 | | | | | |
| 111 | Metaphoxus frequens | | | | | | | | | |
| 112 | Monoculodes spp. | | | 1 | | | | | | |
| 113 | Munida spp. | | | | 1 | 2 | | | | |
| 114 | Nebalia spp. | | | | | 2 | | | | 1 |
| 115 | Orchomene decipiens | | | | | | | | | |
| 116 | Paraphoxus oculatus | | | | | 19 | | | | |
| 117 | Photis spp. | | | | | | | | | |
| 118 | Pleurogonium rubicundum | | | | | | | | | |
| 119 | Prachynella lodo | | | | | | | | | |
| 120 | Rutiderma lomae | | | | | | | | | |
| 121 | Silophasma geminatum | | | | | | | | | |
| 122 | Stenothoidae | | | | | 1 | | | | |
| 123 | Synchelidium shoemakeri | | | | | | | | | |
| 124 | Tanaidae | | | | | | | | | |
| 125 | Westwoodilla caecula | | | | | | | | | |
| 126 | **MOLLUSCA** | MAL1 | MAL2 | MAL3 | MAL4 | MAL5 | MAL6 | MAL7 | MAL8 | MAL9 |
| 127 | Adontorhina cyclia | | | 1 | 1 | 1 | 1 | | | |
| 128 | Bivalvia | | 5 | 1 | 7 | 2 | 2 | 3 | 6 | 4 |
| 129 | Chaetoderma sp. 1 | | 1 | | | 1 | | | 1 | 2 |
| 130 | Chaetoderma sp. 2 | | 2 | 2 | 1 | 2 | | 1 | | |
| 131 | Cidarina cidaris | | | | | | | | | |
| 132 | Cylichna attonsa | | | | | | | | | |
| 133 | Dentalium spp. | | | | | | | 1 | | |

| | A | K | L | M | N | O | P | Q | R | S |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Cape Mudge/Malaspina Strait | MAL1 | MAL2 | MAL3 | MAL4 | MAL5 | MAL6 | MAL7 | MAL8 | MAL9 |
| 134 | Gastropoda | | | | 1 | | 1 | | | |
| 135 | Lucinoma annulata | | | | | | | | | |
| 136 | Macoma spp. | | | 1 | | 4 | 1 | | | |
| 137 | Mytilidae | | | | | | | | | |
| 138 | Nucula tenuis | | | | | | | | | |
| 139 | Nuculanidae | | 1 | 1 | 1 | | | | | |
| 140 | Odontogena borealis | | | | | | | | | |
| 141 | Pectinidae | | | | | 2 | | | 1 | |
| 142 | Scaphopoda | | | | 3 | 2 | | | | |
| 143 | Scintillona bellerophon | 2 | | | 1 | 1 | | | 1 | 1 |
| 144 | Solemya reidi | 1 | | | 2 | 4 | | | | 4 |
| 145 | Tellina spp. | | | | | | | | | |
| 146 | Thyasira gouldii | 1 | 1 | | | | 2 | 1 | 2 | 1 |
| 147 | Turridae | | | | | | | | | |
| 148 | **MISC. TAXA** | MAL1 | MAL2 | MAL3 | MAL4 | MAL5 | MAL6 | MAL7 | MAL8 | MAL9 |
| 149 | Amphiodia spp. | | | | | | | | | |
| 150 | Amphipholis squamata | | | | | | | | | 1 |
| 151 | Apodida | | | | 2 | 1 | | | | |
| 152 | Brisaster latifrons | 2 | 2 | 2 | | 1 | 1 | 1 | 1 | 1 |
| 153 | Campanulariidae | | | | | | | | | |
| 154 | Chiridota spp. | | 1 | 1 | 4 | 2 | 1 | 2 | 6 | 3 |
| 155 | Demospongiae | | | | | P | | | | |
| 156 | Golfingia minuta | | 2 | | | 2 | | | | |
| 157 | Golfingia pugettensis | | | | | | | | | |
| 158 | Golfingia spp. | | | | | | | | | |
| 159 | Leptoplanidae | | | | 1 | | | | | |
| 160 | Lineidae | | | | | | | | | |
| 161 | Micrura spp. | | | | | | | | | |
| 162 | Molpadia intermedia | | | | | | | | | |
| 163 | Nematoda | | | | 1 | 5 | | | | 6 |
| 164 | Ophiura leptoctenia | | | | | | | | | |
| 165 | Ophiura spp. | | | | | 1 | | | | |
| 166 | Ophiurida | | | | | | | | | |
| 167 | Ophiuroidea | | | | | | | | | |
| 168 | Paranemertes spp. | | | | | | | | | |
| 169 | Sertularia spp. | | | | | | | | | |
| 170 | Tubulanus polymorphus | | 1 | | | | | | | |
| 171 | Tubulanus spp. | | | | | | | | | |
| 172 | | | | | | | | | | |
| 173 | ABUN BY REPLICATE | 20 | 54 | 36 | 121 | 226 | 45 | 27 | 41 | 153 |

| | A | T | U | V |
|---|---|---|---|---|
| 1 | Cape Mudge/Malaspina Strait | HAL.2 | PEN. | ABUN |
| 2 | **POLYCHAETA** | | | |
| 3 | Amage anops | | | 2 |
| 4 | Ampharete finmarchica | | | 1 |
| 5 | Ampharete spp. | | | 13 |
| 6 | Amphicteis spp. | | | 1 |
| 7 | Ancistrosyllis groenlandica | | 1 | 62 |
| 8 | Anobothrus gracilis | | | 12 |
| 9 | Aricidea lopezi | | | 57 |
| 10 | Aricidea neosuecica | 25 | 6 | 335 |
| 11 | Aricidea ramosa | | 1 | 52 |
| 12 | Aricidea spp. | | 1 | 103 |
| 13 | Asclerocheilus beringianus | | | 1 |
| 14 | Asychis spp. | | | 1 |
| 15 | Brada sachalina | | | 2 |
| 16 | Capitella capitata complex | | | 3 |
| 17 | Capitellidae | | | 2 |
| 18 | Chaetopteridae | | | 1 |
| 19 | Cirratulidae | | 1 | 20 |
| 20 | Cossura spp. | 1 | | 84 |
| 21 | Decamastus gracilis | | | 6 |
| 22 | Diopatra ornata | | | 1 |
| 23 | Dorvillea rudolphi | | | 9 |
| 24 | Eteone longa | | | 1 |
| 25 | Euclymene cf. zonalis | | | 1 |
| 26 | Euclymene zonalis | | | 7 |
| 27 | Eunice valens | | | 1 |
| 28 | Exogone lourei | | 2 | 90 |
| 29 | Exogone spp. | | | 5 |
| 30 | Galathowenia oculata | | | 144 |
| 31 | Glycera nana | | | 1 |
| 32 | Glycinde armigera | | | 2 |
| 33 | Glycinde picta | | | 1 |
| 34 | Goniada annulata | | | 5 |
| 35 | Goniada brunnea | 1 | 1 | 4 |
| 36 | Gyptis brevipalpa | | 2 | 16 |
| 37 | Heteromastus spp. | | 1 | 1 |
| 38 | Levinsenia gracilis | | 3 | 54 |
| 39 | Levinsenia oculata | | | 2 |
| 40 | Lumbrineridae | 6 | 7 | 98 |
| 41 | Maldane sarsi | | | 3 |
| 42 | Maldane spp. | | 1 | 18 |
| 43 | Maldanidae | | | 59 |
| 44 | Mediomastus spp. | | | 62 |
| 45 | Melinna cristata | | | 7 |

| | A | T | U | V |
|---|---|---|---|---|
| 1 | Cape Mudge/Malaspina Strait | HAL.2 | PEN. | ABUN |
| 46 | Nephtys cornuta | 4 | 3 | 85 |
| 47 | Nephtys punctata | | 2 | 7 |
| 48 | Nepthys ferruginea | | | 12 |
| 49 | Nereis spp. | | | 6 |
| 50 | Nicomache lumbricalis | | | 7 |
| 51 | Notomastus spp. | | | 20 |
| 52 | Notoproctus pacificus | | | 6 |
| 53 | Odontosyllis phosphorea | | | 15 |
| 54 | Onuphis iridescens | | | 20 |
| 55 | Onuphis spp. | | | 6 |
| 56 | Ophelina acuminata | | | 1 |
| 57 | Ophelina breviata | | | 35 |
| 58 | Ophelina groenlandica | | | 1 |
| 59 | Orbinia felix | | | 1 |
| 60 | Owenia fusiformis | | | 9 |
| 61 | Pectinaria californiensis | | | 8 |
| 62 | Pherusa plumosa | | | 11 |
| 63 | Pholoe minuta | | 3 | 6 |
| 64 | Pista bansei | | | 1 |
| 65 | Pista spp. | | | 1 |
| 66 | Polycirrus spp. | | | 13 |
| 67 | Polydora spp. | | | 1 |
| 68 | Polynoidae | | | 30 |
| 69 | Praxillella gracilis | | | 1 |
| 70 | Prionospio spp. | | | 17 |
| 71 | Scalibregma inflatum | | | 3 |
| 72 | Scionella japonica | | | 3 |
| 73 | Scoloplos acmeceps | | | 3 |
| 74 | Sphaerodoropsis sphaerulifer | | | 4 |
| 75 | Spiochaetopterus costarum | | | 1 |
| 76 | Spionidae | | | 43 |
| 77 | Spiophanes berkeleyorum | 1 | | 22 |
| 78 | Spiophanes kroyeri | | | 1 |
| 79 | Spiophanes spp. | | | 3 |
| 80 | Sternaspis scutata | 2 | 1 | 20 |
| 81 | Syllis elongata | 2 | 1 | 53 |
| 82 | Syllis spongiphila | | | 6 |
| 83 | Syllis spp. | | | 21 |
| 84 | Terebellides stroemi | | | 7 |
| 85 | Travisia pupa | | | 5 |
| 86 | Travisia spp. | | | 3 |
| 87 | **ARTHROPODA** | HAL.2 | PEN. | |
| 88 | Ampelisca careyi | | | 4 |
| 89 | Ampelisca spp. | | | 18 |

| | A | T | U | V |
|---|---|---|---|---|
| 1 | Cape Mudge/Malaspina Strait | HAL.2 | PEN. | ABUN |
| 90 | Ampelisca unsocalae | | | 64 |
| 91 | Aoroides spp. | | | 3 |
| 92 | Bathyleberis spp. | | | 5 |
| 93 | Campylaspis spp. | | | 1 |
| 94 | Conchoecia spp. | | | 1 |
| 95 | Copepoda | | | 36 |
| 96 | Cumella spp. | | | 4 |
| 97 | Dexamonica reduncans | | | 5 |
| 98 | Diastylis spp. | | | 3 |
| 99 | Dyopedos spp. | | | 2 |
| 100 | Ericthonius spp. | | | 3 |
| 101 | Eudorella pacifica | 1 | | 78 |
| 102 | Eudorellopsis longirostris | | | 2 |
| 103 | Euphilomedes carcharodonta | | 1 | 6 |
| 104 | Gnathia spp. | | | 4 |
| 105 | Harpiniopsis fulgens | 1 | 4 | 65 |
| 106 | Hippomedon denticulatus | | | 5 |
| 107 | Leptognathia spp. | | | 49 |
| 108 | Liljeborgia cota | | | 2 |
| 109 | Limnoria spp. | | | 56 |
| 110 | Lysianassidae | | | 2 |
| 111 | Metaphoxus frequens | | | 17 |
| 112 | Monoculodes spp. | | | 4 |
| 113 | Munida spp. | | | 4 |
| 114 | Nebalia spp. | | | 3 |
| 115 | Orchomene decipiens | | | 3 |
| 116 | Paraphoxus oculatus | | | 19 |
| 117 | Photis spp. | | | 15 |
| 118 | Pleurogonium rubicundum | 1 | | 6 |
| 119 | Prachynella lodo | | | 1 |
| 120 | Rutiderma lomae | | | 7 |
| 121 | Silophasma geminatum | | | 6 |
| 122 | Stenothoidae | | | 1 |
| 123 | Synchelidium shoemakeri | | | 6 |
| 124 | Tanaidae | | | 7 |
| 125 | Westwoodilla caecula | | | 1 |
| 126 | **MOLLUSCA** | HAL.2 | PEN. | |
| 127 | Adontorhina cyclia | | | 27 |
| 128 | Bivalvia | 2 | 1 | 292 |
| 129 | Chaetoderma sp. 1 | | 1 | 73 |
| 130 | Chaetoderma sp. 2 | | | 22 |
| 131 | Cidarina cidaris | | | 2 |
| 132 | Cylichna attonsa | 1 | | 2 |
| 133 | Dentalium spp. | | 2 | 4 |

| | A | T | U | V |
|---|---|---|---|---|
| 1 | Cape Mudge/Malaspina Strait | HAL.2 | PEN. | ABUN |
| 134 | Gastropoda | | | 10 |
| 135 | Lucinoma annulata | | | 1 |
| 136 | Macoma spp. | | | 6 |
| 137 | Mytilidae | | | 2 |
| 138 | Nucula tenuis | 1 | | 2 |
| 139 | Nuculanidae | 1 | | 6 |
| 140 | Odontogena borealis | 4 | | 33 |
| 141 | Pectinidae | | | 4 |
| 142 | Scaphopoda | 1 | | 20 |
| 143 | Scintillona bellerophon | | | 8 |
| 144 | Solemya reidi | | | 41 |
| 145 | Tellina spp. | | | 1 |
| 146 | Thyasira gouldii | | | 8 |
| 147 | Turridae | | | 1 |
| 148 | **MISC. TAXA** | HAL.2 | PEN. | |
| 149 | Amphiodia spp. | | | 1 |
| 150 | Amphipholis squamata | | | 6 |
| 151 | Apodida | 1 | | 7 |
| 152 | Brisaster latifrons | 1 | 3 | 16 |
| 153 | Campanulariidae | | | P |
| 154 | Chiridota spp. | | 2 | 32 |
| 155 | Demospongiae | | | P |
| 156 | Golfingia minuta | 20 | 1 | 471 |
| 157 | Golfingia pugettensis | | | 10 |
| 158 | Golfingia spp. | | | 1 |
| 159 | Leptoplanidae | | | 3 |
| 160 | Lineidae | | | 1 |
| 161 | Micrura spp. | | | 7 |
| 162 | Molpadia intermedia | | 1 | 1 |
| 163 | Nematoda | | 1 | 199 |
| 164 | Ophiura leptoctenia | | | 54 |
| 165 | Ophiura spp. | 2 | | 24 |
| 166 | Ophiurida | | | 27 |
| 167 | Ophiuroidea | | | 12 |
| 168 | Paranemertes spp. | | | 1 |
| 169 | Sertularia spp. | | | P |
| 170 | Tubulanus polymorphus | | 1 | 8 |
| 171 | Tubulanus spp. | | | 1 |
| 172 | | | | |
| 173 | ABUN BY REPLICATE | 79 | 55 | 3837 |

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